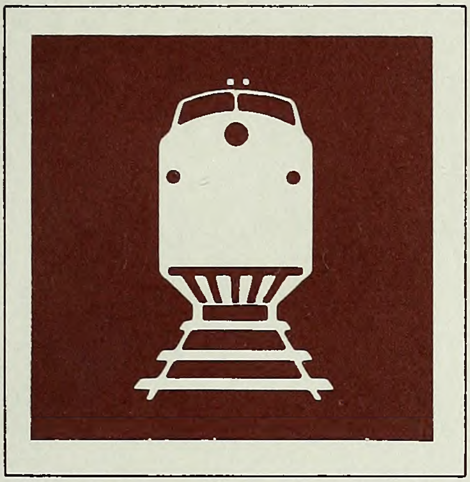
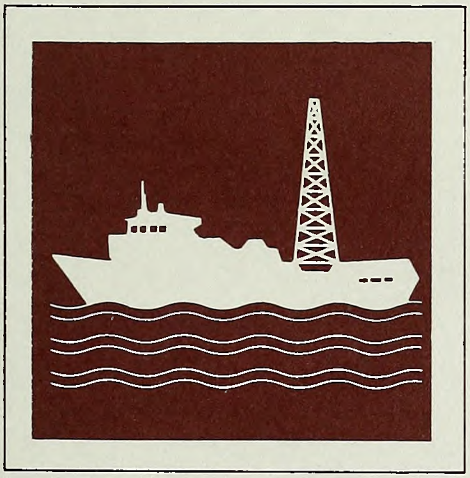
Coastal Energy Transportation Study
Phase III, Volume 3
Impacts of Increased Rail Traffic on Communities in Eastern North Carolina

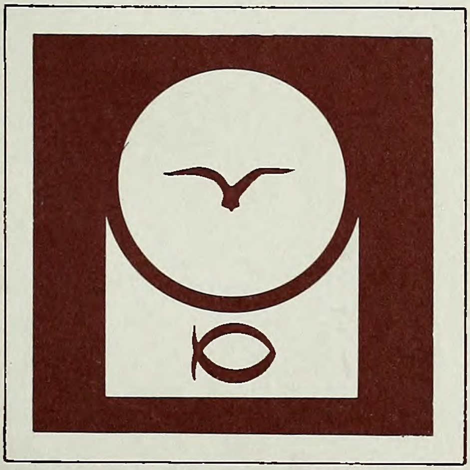


John R. Stone
Michael T. Stanley
Paul T. Tschetter
UNC Institute and Transportation Research and Education
P.O. Box 12551
Research Triangle Park, NC 27709



AUGUST 1982

North Carolina
Coastal Energy Impact Program
Office of Coastal Management
North Carolina Department of Natural Resources
and Community Development



CEIP REPORT NO. 17

To order:

Residents of North Carolina may receive a single copy of a publication free upon request. Non-residents may purchase publications for the prices listed. Because of the production costs involved, some of the publications carry a minimal charge regardless of residency. Prices for these are indicated in the price list as being "for all requests".

When ordering publications please provide the publication number and title and enclose a check made payable to DNRCD. For a complete list of CEIP publications - or to place an order - contact:

Coastal Energy Impact Program
Office of Coastal Management
N.C. Department of Natural
Resources and Community
Development
Box 27687
Raleigh, NC 27611

Series Edited by James F. Smith
Cover Design by Jill Miller

Coastal Energy Transportation Study

Phase III, Volume 3

Impacts of Increased Rail Traffic on Communities in Eastern North Carolina

by

John R. Stone

Michael T. Stanley

Paul T. Tschetter

UNC Institute for Transportation Research and Education
P.O. Box 12551
Research Triangle Park, N.C. 27709

The preparation of this report was funded by a Coastal Energy Impact Program grant from the North Carolina Coastal Management Program, through funds provided by the Coastal Zone Management Act of 1972, as amended, which is administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration. The CEIP grant was part of NOAA grant NA-80-AA-D-CZ149.

Project No. 80-07
Contract No. C-6041

August 1982

PREFACE

This report is the third of four reports from Phase III of a three-phase study funded by the Coastal Energy Impact Program and conducted by the UNC Institute for Transportation Research and Education. Phase I of this study, conducted in 1980, identified and documented the transportation needs necessary to support a group of energy projects proposed for the coastal area of North Carolina. Phase II of this study, conducted from September 1980 to August 1981, had two distinct parts:

1. An assessment of impacts of the Outer Continental Shelf (OCS) oil and gas exploration and production activity with emphasis on the transportation requirements and alternative locations for on-shore support base(s) in North Carolina, and
2. An assessment of impacts of coal exports from North Carolina with emphasis on the transportation requirements of alternative locations and capacities of coal terminals.

Phase III of the Coastal Energy Transportation Study, conducted from September 1981 to August 1982, is an assessment of specific technologies for handling coal and other commodities at marine terminals, the competing impacts of energy transport and development of the recreational and other industrial sectors of the economy, and a detailed analysis of rail transportation through eastern North Carolina to the State's port cities of Wilmington and Morehead City. The four reports prepared under Phase III are entitled:

1. Volume 1: Alternative Technologies for Transporting and Handling Export Coal, by Paul D. Cribbins and R. Daniel Latta. (January 1982, CEIP Report No. 12).
2. Volume 2: Projected Demands on Coastal Area Transportation Systems Resulting from Recreational and Industrial Development, by Paul D. Tschetter, et al. (In preparation).
3. Volume 3: Impacts of Increased Rail Traffic on Communities in Eastern North Carolina, by John R. Stone, et al, August 1982.
4. Volume 4: The Potential for Wide-Beam, Shallow-Draft Ships to Serve Coal and Other Bulk Commodity Terminals along the Cape Fear River, by Paul D. Cribbins, August 1982.

Separate reports were prepared documenting the results of Phase I and Phase II. These previously published reports are entitled:

1. Coastal Energy Transportation Study: Phase I, An Analysis of Transportation Needs to Support Major Energy Projects in North Carolina's Coastal Zone. (December 1980, CEIP Report No. 1).
2. Coastal Energy Transportation Study: Phase II Volume 1, A Study of OCS Onshore Support Bases and Coal Export Terminals. (August 1981, CEIP Report No. 2).

3. Coastal Energy Transportation Study: Phase II Volume 2, An Assessment of Potential Impacts of Energy-Related Transportation Developments on North Carolina's Coastal Zone. (January 1982, CEIP Report No. 3).

4. Coastal Energy Transportation Study: Phase II Volume 3, An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone. (August 1981, CEIP Report No. 4).

All of these reports are available from the Office of Coastal Management, North Carolina Department of Natural Resources and Community Development, Raleigh, N.C.

The scheduling of the various tasks for each phase of the study was designed to permit the study team to complete key activities in advance of certain critical dates. For example, many of the tasks related to OCS activity in Phase II were completed so that state, regional, and local decision-makers involved in the OCS program would have output prior to August 1981, the scheduled date for OCS Lease Sale #56 by the Bureau of Land Management.

The movement of export coal shipments through North Carolina is now underway. The contract with Alla-Ohio Coal Company to ship three million tons annually through the State Ports Authority (SPA) facilities in Morehead City was announced in October 1980; and the first shipment of export steam coal left Morehead City for Holland on May 13, 1981. Although the situation regarding the development of energy projects is constantly changing, this report is based on the most up-to-date information available at the time of printing.

The purpose of the Coastal Energy Transportation Study is to provide state and local governmental officials and policy-makers with sufficient background data and scenario analysis to permit informed, rational decision-making for energy- and transportation-related development activities affecting the state in general and the coastal zone specifically. The eight reports of this study (Phase I; Phase II Volumes 1, 2, and 3; and Phase III Volumes 1, 2, 3, and 4) are not to be construed as either engineering analyses or as economic/feasibility studies sufficient by themselves to justify (or reject) specific alternatives of any development activity. Instead, the reports should be used as tools to effect better management of the state's resources and activities.

CONTENTS

FIGURES

TABLES

ACKNOWLEDGEMENTS

SPONSOR

COASTAL ENERGY IMPACT PROGRAM (CEIP)
North Carolina Department of Natural Resources and Community Development

Joseph W. Grimsley, Secretary
Kenneth D. Stewart, Director,
Office of Coastal Management
James F. Smith, CEIP Coordinator

RESEARCH ORGANIZATION

INSTITUTE FOR TRANSPORTATION RESEARCH AND EDUCATION (ITRE)
The University of North Carolina

Edwin W. Hauser, Project Manager and Chairman of Advisory Committee;
Deputy Director, ITRE

John R. Stone, Principal Investigator
Assistant Professor, Civil Engineering
North Carolina State University

Paul T. Tschetter, Project Associate
Associate Professor, Sociology
East Carolina University

Michael T. Stanley, Project Associate
Research Assistant
Institute for Transportation Research and Education

R. Daniel Latta, Project Associate
Research Assistant
Institute for Transportation Research and Education

Zaneta G. Walker
Research Assistant
Institute for Transportation Research and Education

Mary Beth Thurman
Project Secretary
Institute for Transportation Research and Education

COMMUNITY CONTACTS

William H. Batchelor
City Manager
Rocky Mount

Karen Bender
Traffic Engineer
Rocky Mount

Ann Pridgen
Emergency Services
Rocky Mount

T. Bruce Boyette
City Manager
Wilson

Harry W. McVey
Chief Planner
Wilson

C.R. Southerland
Director of Public Works
Goldsboro

C. David Ham
City Engineer
Goldsboro

Alfred Herring
Administrative Clerk
Warsaw

William B. Farris
Assistant City Manager
Wilmington

Mark D. Ahrendsen
Transportation Planner
Wilmington

James J. Jefferies
Commissioner of Public Safety
Boiling Spring Lakes

E.C. Stanley
Chairman, Mayor's Railroad Committee
Boiling Spring Lakes

P.A. Averette
Finance Officer
Greenville

Gail Meeks
Acting City Manager
Greenville

Anthony I. Hooper
City Manager
New Bern

David Rowland
Planner
New Bern

Robert Brigman
City Manager
Kinston

Donald Davis
City Manager
Morehead City

James Griffin
Fire Chief
Morehead City

Coastal Energy Transportation Study

PROJECT ADVISORY COMMITTEE

Mark Ahrendsen, Transportation Planner
City of Wilmington

Steven Benton, Head, Technical Services
Office of Coastal Management

Donald Davis, Town Manager
Town of Morehead City

Jerry Ganey, Director of Special Projects & Property Control
State Ports Authority

Ralph L. Godwin, Executive Director
Wilmington Industrial Development, Inc.

Billy Ray Hall, Assistant Secretary
Division of Policy Development
NC Department of Administration

Edd Hauser, Deputy Director
Institute for Transportation Research and Education
(Chairman)

Tony Hooper, City Manager
City of New Bern

Mary Ellen Marsden, Research Associate
Institute for Research in Social Science
University of North Carolina at Chapel Hill

Bruce Muga, Professor of Civil Engineering
Duke University

Margaret Riddle, Coordinator
Office of Policy and Planning
NC Department of Administration

Angela G. Skelton, Associate Director
North Carolina Petroleum Council

James F. Smith, CEIP Coordinator
Office of Coastal Management
NC Department of Natural Resources and Community Development
(ex-officio member)

Yates Sorrell, Technical Director
Alternative Energy Corporation
(Co-Chairman)

Roy Stevens, Executive Director
Carteret County Economic Development Council, Inc.

Pearson Stewart, Assistant Secretary for Planning
NC Department of Transportation

Eric A. Vernon, Coordinator
OCS Task Force, Office of Marine Affairs
NC Department of Administration

John Warren, President
Sunbelt Hydro Corporation

Paul Wilms, Head, Planning and Environmental Studies
Environmental Management Division
NC Department of Natural Resources and Community Development

ABSTRACT

This study estimates the positive and negative impacts of increased rail traffic on communities in eastern North Carolina. The positive impacts include estimates of rail and port-related employment and payroll increases that could be expected if major increases in the annual volume of any bulk commodity, such as coal, were to be exported from Morehead City or Wilmington. The negative impacts focus on vehicle/train, at-grade crossing conflicts, such as traffic delay, emergency vehicle delay, accidents, fuel use, and pollution. Alternative solutions are suggested for the problems various communities may encounter.

A "case study" approach has been taken in this study, with 10 local communities providing data for analysis. Seven "problem specific" solutions to increased rail traffic in these communities were analyzed: rail by-pass, grade separation, street widening, emergency services/railroad communications, fire/medical services for isolated neighborhoods, grade crossing warning devices, and city ordinances. Needs for these types of improvements in the towns of New Bern and Morehead City alone total about $90,000,000. In the other eight case study communities, needs for capital improvements to accommodate increased rail traffic total approximately $16,000,000. These needs are based on an assumed 20 million tons of export commodities annually through <u>either</u> of the two port cities (Morehead City or Wilmington).

On the basis of these results, major commodity flows in the Wilmington rail corridor would have fewer vehicle/train impacts than rail traffic in the Morehead City corridor. All other factors being equal, it is recommended that priority be given to promoting rail traffic in the Wilmington corridor.

COAL TRANSPORTATION IN COASTAL NORTH CAROLINA

In 1980 and 1981 the State of North Carolina was faced with numerous proposals for large-scale facilities for shipping coal from North Carolina ports. Transportation of this coal through the coastal zone would affect many communities along the rail lines. It would also affect the terminal cities--Morehead City and Wilmington--through both rail traffic and port development. In order to prepare state and local agencies for dealing with these impacts, a major effort was organized under the sponsorship of the Coastal Energy Impact Program to discover these impacts, quantify and analyze them, and to propose mitigation measures. This present report is one of four reports which have resulted from this effort. In addition, closely related reports have been prepared on port development at Radio Island near Morehead City, alternative technologies for moving coal, and the alternative of wide-beam shallow-draft colliers for Wilmington. Those reports are listed in the list of CEIP Publications in the back of this report.

<u>Impacts of Increased Rail Traffic on Communities in Eastern North Carolina (CEIP Report No. 17)</u>

This study estimates the positive and negative impacts of increased rail traffic on communities in eastern North Carolina. The positive impacts include estimates of rail and port-related employment and payroll increases that could be expected if major increases in the annual volume of any bulk commodity, such as coal, were to be exported from Morehead City or Wilmington. The negative impacts focus on vehicle/train, at-grade crossing conflicts, such as traffic delay, emergency vehicle delay, accidents, fuel use, and pollution. Alternative solutions are suggested for the problems various specific communities may encounter.

A case study approach has been taken in this study, with ten local communities providing data for analysis. Seven "problem specific" solutions to increased rail traffic in these communities were analyzed: rail by-pass, grade separation, street widening, emergency services/railroad communications, fire/medical services for isolated neighborhoods, grade crossing warning devices, and city ordinances. Needs for these types of improvements in the towns of New Bern and Morehead City alone total about $90,000,000. In the other eight case study communities, needs for capital improvements to accommodate increased rail traffic total approximately $16,000,000. These needs are based on an assumed 20 million tons of export commodities annually through <u>either</u> of the two port cities (Morehead City or Wilmington). On the basis of these results, major commodity flows in the Wilmington rail corridor would fewer vehicle/train impacts than rail traffic in the Morehead City corridor. All other factors being equal, it is recommended that priority be given to promoting rail traffic in the Wilmington corridor.

<u>Analysis of the Impact of Coal Trains Moving through Morehead City</u> (CEIP <u>Report No. 25)</u>

This report examines the possibility of any adverse effects to the town of Morehead City and its citizens caused by the coal train transportation. Impacts are estimated for tonnages of three million and 15 million tons of coal per year. Field measurements under current conditions (coal trains at about a one million ton per year rate) were made of vibration

and traffic. Traffic delay and business effect studies were also conducted. Special attention was given to the impacts of train-caused vibrations on utility lines buried under or near the tracks.

<u>Coal Movements through the City of Wilmington</u> (CEIP Report No. 26)

This study identifies and analyzes the potential economic, transportation, and environmental impacts to the City of Wilmington caused by the export of coal through the State Port. Primary attention focuses on the effects of unit train movements. Special attention is given to effects on several neighborhoods which were chosen to reprent the full array of socio-economic patterns found along the rail line. Public policy actions are recommended to reduce adverse impacts.

<u>New Bern Coal Train Study</u> (CEIP Report No. 24)

This project, which is still underway, studies the impacts of coal trains on historic structures in New Bern. Extensive vibration studies and engineering analyses of historic buildings have been undertaken. Protective measures are expected to be recommended.

1.0 EXECUTIVE SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

1.1 Introduction

This report documents a study conducted by the University of North Carolina Institute for Transportation Research and Education in 1982. The purpose of the study was to estimate the positive and negative impacts of increased rail traffic on communities in eastern North Carolina. In addition the study was designed to identify conflicts such as vehicle delay, emergency service delay, and accidents. The focus of the study is on traffic impacts; environmental, noise, and vibration impacts are not considered.

Without the involvement of a number of participants this study could not have been completed. Participants at the state level were the North Carolina Department of Natural Resources and Community Development and the Department of Transportation. Participating communities were Rocky Mount, Wilson, Goldsboro, Warsaw, Wilmington, Boiling Spring Lakes, Greenville, New Bern, Kinston, and Morehead City.

It is anticipated that the results of this study will be used as a first step in identifying the relative needs of the communities along the rail corridors leading to the two state ports at Morehead City and Wilmington. Additional steps including on-site evaluation and detailed design analysis, which are beyond the scope of this report, will be needed when the outlook for major increases in rail traffic becomes more certain.

1.2 The Problem

Properly planned for and managed, increased rail traffic promises economic growth and development for North Carolina. However, state and regional progress might be bought at the price of localized disruption unless the adverse effects of rail movements through communities are identified and ameliorated. Port activities associated with rail shipments can

serve as vital catalysts to the generation of employment, payroll, and tax revenue in the immediate port area. The "rippling" economic effects of vibrant port activities can spread jobs and dollars throughout the region surrounding the port. But for inland communities along train corridors, negative impacts would be greater than any anticipated economic benefit in a particular community. In these towns long trains can simultaneously block many crossings and effectively isolate parts of a community for brief periods of time. This means the potential for more grade crossing accidents, frustrating delays for motorists, and sometimes the loss of precious minutes to emergency service providers. In addition, some town officials believe the trains will degrade the attractiveness of their communities and threaten economic and residential development.

Because of the projected increase in rail traffic, especially coal shipments, there is a growing concern about rail/community conflicts. In response, state and local officials have already begun the task of developing answers for the port communities of Wilmington and Morehead City and for the historic town of New Bern. Among the solutions proposed are grade separations, rail bypasses, and barge and pipeline alternatives. Such actions are not only costly to the state and railroads, but also create an entirely different set of environmental, cultural, and other problems for the communities. Furthermore, application of these solutions to all problem crossings in the corridor would be prohibitively expensive. Hence, low cost solutions such as improved grade crossing protection, better emergency service/train communication, expanded emergency services, and the like need to be considered wherever they are feasible.

1.3 The Study Approach

To help resolve questions about the impacts of increased railroad traffic on communities in eastern North Carolina, the North Carolina Department of Natural Resources and Community Development, through its Coastal Energy Impact Program, sponsored this study. It is divided into several tasks:

1. Identify the prospects of increased rail traffic and the affected communities.
2. Collect data from a selected group of the affected communities and other sources regarding the types of rail/community conflicts experienced and the characteristics of existing rail operations, crossing locations, and vehicle traffic.

3. Estimate the beneficial economic impacts from increased rail traffic.
4. Estimate the current and future levels of negative vehicle/train impacts.
5. Propose solutions to mitigate the adverse impacts.

During the study 83 grade crossings in ten communities were analyzed. General impacts for additional crossings in suburban and rural areas throughout 15 eastern North Carolina counties were also assessed. Impact magnitudes were estimated for traffic delay, medical service delay, fire response delay, grade crossing accidents, and the traffic-delay-related impacts of fuel use, pollutants, and travel time cost at grade crossings.

Besides these negative impacts from increased rail traffic, direct and indirect positive impacts were estimated using coal shipments as an example. The direct benefits from coal shipments include more jobs and increased payrolls and tax revenues. Indirect benefits result from a multiplier effect associated with port and perhaps rail employment. In addition, improved port facilities may attract new industry and commerce. Benefits from increased rail traffic were estimated so that they could be compared to the negative impacts and the costs of their mitigation.

1.4 Study Findings

An in-depth analysis of the rail-related problems in ten corridor communities and at five representive rural crossings was conducted. The ten communities include the seven largest communities and three representative small towns along three rail corridors to the state ports. The communities range in population from about 1,000 to 44,000. Estimates of problem magnitudes are shown in Table 1-1. These estimates, which represent annual totals for each community, suggest a wide range of problem magnitudes if as many as 12 additional daily trains pass through each of the rail corridors. The reader should note that this is an estimate of the number of additional trains needed to increase the volume of export tonnage from its current 1.5 million tons annually (MTA) to 20 MTA. Current movements of trains to the Morehead City coal terminal average one per day. Controlling for population size, however, reveals less diverse relative problem magnitudes (Table 1-2). Such information can be used to assess which locations may experience the largest composite impact from rail operations.

Table 1-1

Estimated Future Problem Magnitudes in the Case Study Communities

Community	% Increase in Rail Traffic [1]	Vehicle Delay Cost Per Year ($)	Medical Delays and Route Deviations Per Year	Fire Delays and Route Deviations Per Year	Vehicle/Train Accidents Per Year
Rocky Mount	75	243,000	110	2 - 5	.32
Wilson	109	1,105,000	1548	3 - 6	1.47
Goldsboro	600	357,000	72	4 - 8	2.31
Warsaw	400	15,000	5	0	.26
Wilmington	600	939,000	47	27	3.80
Boiling Spring Lakes	600	15,000	3	0	.14
Greenville	300	813,000	88	0 - 4	1.89
New Bern	300	602,000	53	4 - 8	1.28
Kinston	600	536,000	21	7 - 14	1.79
Morehead City	600	1,727,000	111	0 - 7	2.05

[1] Assumed increase in rail traffic of 12 trains per day on each corridor. Such an increase would occur, for example, if coal shipments from North Carolina ports were to grow to 20 million tons annually (MTA) to either of the two port cities (Wilmington or Morehead City). Present volume of export coal from Morehead City is 1.5 MTA with a design capacity of 3.0 MTA. The 20 MTA estimate is currently considered the maximum feasible tonnage through either port and, in all likelihood, will not reach this volume in the next 10 years. The figures above, therefore, are for a "worst case" situation that is likely to occur during that time period.

Table 1-2

Annual Per Capita Magnitudes of Selected Future Community Problems[1]

Community	Population	Vehicle Delay Costs ($/Person/Year)	Medical Delays (No./Pers./Yr.)	Fire Delays (No./Pers./Yr.)	Vehicle/Train Accidents (No./Pers./Yr.)
Rocky Mount	42,418	5.72	.0026	.0001	.000008
Wilson	34,328	32.10	.0450	.0001	.00004
Goldsboro	33,899	10.52	.0021	.0002	.00008
Warsaw	2,950	5.04	.0037	--	.00009
Wilmington	44,000	21.34	.0013	.0006	.00009
Boiling Spring Lakes	998	15.49	.0010	--	.00014
Greenville	35,740	22.74	.0025	.0001	.00005
New Bern	14,557	41.35	.0036	.0008	.00009
Kinston	25,234	21.23	.0008	.0004	.00007
Morehead City	15,803[2]	109.29	.0106	.0002	.00013

[1]See footnote Table 1-1.

[2]Population for Morehead Township which includes Atlantic Beach.

On a per capita basis it is seen from Table 1-2 that Morehead City, New Bern, and Wilmington will have very negative rail impacts. These results are also documented in other reports (NCDOT 1980, 1981, 1982; Anderson and Associates, 1982). Table 1-2 further shows that should major increases in rail traffic occur, Wilson, Greenville, Goldsboro, and Kinston will experience considerable rail/community conflicts. Goldsboro and Wilson are especially critical because north-south and east-west traffic from both ports could intersect there, and rather than 12 new daily train movements, these towns could experience 24 movements under the rail traffic assumptions of this report.[1]

Depending on the community and its type of problem, a range of solutions present themselves. As Table 1-3 shows, some solutions are high cost, some are low cost. Neglecting non-quantifiable social and environmental costs, the totals of these costs, minus any amounts paid by rail or coal companies, can be compared to the benefits generated by increased rail traffic in order to estimate a rough regional benefit/cost ratio for the commodity being shipped. The overall results of Table 1-3 suggest that in order for 12 additional daily train movements to occur in the port corridors, approximately $90-$100 million worth of capital improvement projects would be required to alleviate rail/community conflicts (track and road bed improvements are not included, nor are the costs of any environmental mitigation measures. The Southern Railway route through Goldsboro, Kinston, and New Bern to Morehead City may need as much as $65 million worth of improvements; that through Wilson, Greenville, and New Bern to Morehead City, $90 million. The Seaboard route from Rocky Mount to Wilmington will require approximately $8 million in grade crossing improvements.

Thus, it would seem that if coal or other rail shipments were to increase substantially in the future, the Wilmington corridor would be preferable because of the fewer number of rail/community impacts and the lower cost of mitigating them.

---

[1]Other communities not included in this series of case studies could also experience the projected impacts. Obviously, if fewer (or more) than 12 additional trains per day were to use any particular rail corridor, the projected impacts would be less (or greater).

TABLE 1-3 Estimated Cost of Solutions to Community Rail Impacts

City	Solutions	Cost			
		Itemized		Total	
		Capital	Annual	Capital	Annual
Rocky Mount				$ 1,000	$ 100
	1. Emergency service/RR communications system	$ 1,000	$ 100		
Wilson[3]				8,446,000	30,100
	1. Grade separation (2)[1]	6,000,000			
	2. Street widening (2)[1]	2,000,000			
	3. Emer. svc./RR communications system	1,000	100		
	4. Rescue squad	25,000	25,000		
	5. Crossing predictors (5)[2]	300,000	5,000		
	6. Signal adjustments (3)[2]	120,000			
Goldsboro[3]				701,000	15,100
	1. Emer. svc./RR communications system	1,000	100		
	2. Gates (4)[4,5]	240,000	4,000		
	3. Flashing lights (9)[4]	360,000	9,000		
	4. Lights & gates (1)[4]	100,000	2,000		
Warsaw				146,000	27,100
	1. Emer. svc./RR communications system	1,000	100		
	2. Rescue squad	25,000	25,000		
	3. Gates (2)[5]	120,000	2,000		

[1]Tarboro St., & Goldsboro St.

[2]GCP's (grade crossing protectors) applied to crossings w/gates. Crossings w/flashers are given signal timing adjustments for some set train speed.

[3]Wilson and Goldsboro are the only two cities for which a 20 MTA throughput has been estimated for both the Seaboard Coastline and Southern routes (combined). All other communities show costs based on rail traffic over a single corridor

TABLE 1-3 cont.

City	Solutions	Cost			
		Itemized		Total	
		Capital	Annual	Capital	Annual
Wilmington				$ 6,461,000	$ 8,000
	1. Grade separation (2)[6]	$ 6,000,000	$		
	2. Emer. svc/RR communications system	1,000	100		
	3. Gates (7)[4,5]	420,000	7,000		
	4. Flashing lights (1)[4]	40,000	1,000		
Boiling Spring Lakes				120,000	3,000
	1. Flashing lights (3)	120,000	3,000		
Greenville				181,000	1,100
	1. Emer. svc/RR communications system	1,000	100		
	2. Crossing predictors (1)[2]	60,000	1,000		
	3. Signal adjustments (3)[2]	120,000			
New Bern				55,321,000	7,100
	1. Emer. svc/RR communications system	1,000	100		
	2. Gates (2)[4]	120,000	2,000		
	3. Flashing lights (5)[4]	200,000	5,000		
	4. Bypass[7]	55,000,000			

[4] 5000 ADT used as cutoff. Less than 5000 ADT implies flashers. Greater than 5000 ADT implies gates.

[5] Cost figure shown assumes that the cost of adding gates only (to crossings which already have flashers) is the difference between the cost of flashers only and the cost of both, or $60,000. O&M cost is also assumed to be the difference of the respective costs.

TABLE 1-3 cont.

City	Solutions	Cost			
		Itemized		Total	
		Capital	Annual	Capital	Annual
Kinston				$ 561,000	$ 12,100
	1. Emer. svc/RR communications system	$ 1,000	$ 100		
	2. Gates & crossing predictors (4)[2,4,5]	400,000	8,000		
	3. Flashing lights (4)[4]	160,000	4,000		
Morehead City				34,526,000	25,100
	1. Rail bypass[8]	28,000,000			
	2. Grade separations (3)[9]	6,500,000			
	3. Emer. svc/RR communications system	1,000	100		
	4. Rescue squad	25,000	25,000		
Total Costs				$106,464,000	$128,900

[6]Market St., & Oleander St.

[7]NCDOT design alternative.

[8]NCDOT (1982)

[9]US 70 at Newport and SR 1177 east of Morehead City (NCDOT, 1982)

1.5 Conclusions

There are two major conclusions. First, the costs of state port development depend on the rail transportation impacts on inland communities, as well as the impacts on the port area itself. This is the first study which has recognized the regional implications of developing increased commerce through Morehead City and Wilmington. Second, as a result of fewer grade crossing conflicts and lower costs associated with the Wilmington corridor. the shipment of bulk commodities should be encouraged through Wilmington more than through Morehead City.

In addition, this study has made several significant contributions to the understanding and resolution of rail/community conflicts in eastern North Carolina. The basic problems experienced by ten case study communities and their causes were clarified. Methods providing for problem identification and measurement on a regional basis were developed and applied; and low cost, as well as high cost, actions to reduce rail/community conflicts were recommended as potential solutions.

With regard to the case study communities themselves, the most critically impacted were Morehead City, New Bern and Wilmington. Goldsboro and Wilson are two more potential "hot spots" because both Southern and Seaboard Coast Line traffic may pass through the towns if future rail movements to both ports increased. Other communities will be impacted in lesser degrees.

Comparing the costs and the benefits of increased rail traffic, and using 20 million annual tons of coal exports as an example, it was found that if coal were to begin moving out of Wilmington, approximately $8 million worth of grade crossing and other improvements would be needed in the corridor communities, but that nearly $6 million in annual wages would be added to the regional economy, primarily in the Wilmington area. On the other hand, if similar amounts of coal were to move from Morehead City, approximately $65-$90 million worth of grade crossing and other improvements would be required to generate the same $6 million in annual wages. To complete the benefit-cost picture, consideration must be given to other factors--tax revenues, lease agreements, commerce and industry development, environmental damage, the public-private sharing of mitigation costs, etc.

Looking more closely at the negative impacts of increased rail movements through eastern North Carolina, the following points may be made.

a. Regional Employment

Unless the commodity being shipped originates in North Carolina, the majority of any employment increases will occur out-of-state. In the case of coal exports, less than 10% of the total resulting increased employment is likely to occur in North Carolina. Including port activity, rail transportation, and business opportunities, the new jobs in North Carolina resulting from the shipment of 20 MTA on each corridor will be on the order of 2,000 to 3,000. Out-of-state mining interests would see their employment increase by roughly 36,000. Of the 2,000 to 3,000 North Carolina jobs, perhaps as many as 300 would occur in the railroad sector, 400 in the port area, and the remainder in support industries and community businesses.

b. Rail/Community Conflicts

If a total of 20 million tons of coal are exported from either North Carolina port area (Morehead City or Wilmington), as many as 30 unit train movements to and from the ports will occur daily. Typically, communities along the routes will encounter 12 to 15 of these movements since the routes are different for the two ports; but in Wilson or Goldsboro the routes will intersect, and one of these communities will encounter all of the movements. Needless to say, the coal trains necessary to move this volume of coal or any other commodity through North Carolina will represent a substantial increase over existing rail traffic. The primary impacts for inland communities appear to be traffic-related as discussed below.

c. Traffic Delay at Grade Crossings

Traffic delay consists not only of the time that a crossing is actually blocked by a train, but also the time it takes the traffic queue to dissipate and the traffic flow to return to normal. For typical streets the total delay may be twice the actual blocked crossing time of 5 to 10 minutes; for worst case situations the total delay may exceed one hour for each passing train. For the case study communities, approximately 150,000 vehicle-minutes of additional delay will occur

each day as a result of 12 new daily train movements. This delay is roughly equivalent that occurring at 150 typical traffic signals.

d. Emergency Vehicle Delays and Route Deviations

Medical, fire, and police emergency responses can be delayed at railroad grade crossings. Not only can the responding vehicles be delayed, but also volunteers. While emergency vehicle delay is ranked as a major problem nationally, the North Carolina case study communities are not that concerned. Multiple emergency services (especially fire stations) are often located throughout a community thus reducing the likelihood of an emergency responder being delayed. Of the 7,500 annual fire responses in the case study communities, less than one percent are likely to be delayed at crossings or diverted to longer routes. About eight percent of the 24,000 medical emergencies will be similarly affected.

e. Grade Crossing Accidents

Communities are concerned with safety at grade crossings. They recognize the danger to school buses and pedestrians, as well as that to general vehicular traffic. Considering all types of vehicular accidents, it was found that unless protection is improved at virtually all affected crossings, then the accident rate will be two to four times the average rate for the state. Actual numbers of accidents are likely to be from about seven annually to about sixteen for all the crossings analyzed.

1.6 Recommendations

The results of this study must be interpreted as the first step in identifying potential rail/community trouble spots and in suggesting possible solutions. Future, more detailed, design oriented studies are required before more than the "order of magnitude" impact and cost estimates of this report can be made. Similarly, additional analysis is also needed to estimate the total benefits from additional jobs. In this regard, the following recommendations are made for future study should increased rail traffic in the port corridors become more probable:

1. Consider system-wide transportation costs and regional impacts in the port development process.

2. Promote the shipment of coal and other bulk commodities through the corridor to Wilmington because of fewer impacts and less costly mitigation measures.

3. Visit the communities and confirm the results of this report; i.e., obtain a consensus that the potential problems identified in this report are actually those that the communities perceive.

4. Visit problem crossings in the critical communities and collect site-specific design data for the alternatives given in this report.

5. Conduct an analysis of the alternatives to determine the amount by which the various impacts are mitigated. If the impact alleviation is insufficient, choose the next most "potent" alternative.

6. Identify funding sources.

7. Pick the most critical crossings and begin design and implementation.

8. Conduct an economic impact study to accurately estimate the total benefits from increased rail shipments.

9. Systematically combine all the costs and benefits of increased rail traffic and determine the overall value of such traffic to the region and the state vis-a-vis other transportation investment alternatives.

10. Extend this analysis to include small town and rural crossings omitted from the case study locations.

11. Whenever possible promote transportation improvements and other state investments which directly and primarily support the growth of in-state employment and business.

2.0 LIKELIHOOD FOR INCREASED RAIL TRAFFIC

The likelihood for increased rail traffic in eastern North Carolina is moderate to high. Already there are export coal shipments which began in 1981 and may multiply ten-fold by 1995. Additional coal shipments may also occur as regional electric power companies modify their plans for future expansion and switch from nuclear to coal-fired plant designs. Furthermore agricultural, mineral extraction, industrial, and outer continental shelf energy developments are likely to lead to increased rail traffic. The following sections explore these possibilities in more detail.

2.1 Coal Trains

Since 1981, eastern North Carolinians have focused much attention on the prospects for export coal train movements to the ports of Morehead City and Wilmington. In early 1981, Alla-Ohio Valley (A.O.V) Industries developed a coal terminal at the state-run port in Morehead City. Between May and November 1981, A.O.V. moved about 1.0 million tons of coal through the facility and then ceased operations for five months. They began again in April 1982 at a rate somewhat under the maximum allowable rate of 3.0 million tons annually. While no other coal export operations are currently underway in North Carolina, coal companies are developing plans to ship coal from Radio Island near Morehead City and from several sites near Wilmington.

Depending on one's predisposition to coal impact issues, the future may look bright indeed for North Carolina coal exports. According to figures from the North Carolina Department of Natural Resources and Community Development, two additional coal terminals have been proposed for Morehead City and six have been proposed for Wilmington (NCDNRCD, 1981). If coal companies build all the proposed terminals, nearly 90 million tons could be shipped annually from North Carolina. This figure represents 70% of the anticipated U.S. share of the world steam coal market in 1990,

and 22% of the U.S. market in the year 2000. Considering the competition with established coal terminals in Baltimore, Hampton Roads, and other ports, however, it is unlikely North Carolina will capture such a major share of the foreign market for U.S. steam coal. More conservative planners are currently estimating that 40 million tons annually (MTA) split evenly between Morehead City and Wilmington, will move through North Carolina. This figure may also be too high depending on the volitility of the world coal market and local decisions regarding coal terminal development. Indeed, Carol Coal, the only firm which has announced plans to site a terminal at the State Port in Wilmington, has decided to shelve its plans indefinitely in the face of declining European coal markets. Williams Terminal has also withdrawn its option on a site south of Wilmington. Furthermore, the citizens of Wilmington voted against having coal terminals within city light industrial zones (Wilmington Morning Star, June 26,30, 1982). Plans are still pending, however, for major terminals to be built on Radio Island by A.O.V.(10-15 MTA) and Gulf Interstate (5-20 MTA), in Pender County by Wheelabrator-Frye (12-14 MTA), and in Brunswick County by Utah International (5-7 MTA). Whether or not these terminals are built remains to be seen, but the facts are that U.S. coal will be a major world energy source for the next 20 years and that new U.S. port capacity must be built to move it. In the future North Carolina may yet provide part of this needed port capacity in spite of the present cooling of the Carolina coal fever.

Besides coal bound for export, 24 million annual tons of coal currently move in North Carolina to fire Duke and Carolina Power and Light (C.P.L.) electric plants. Most of this coal moves in western North Carolina with an average of 1 to 5 trains per day on track sections near Charlotte (Southern Railway, 1980). In the eastern part of the state, one train per week moves to the C.P.L. Sutton plant near Wilmington via Lumberton, and one train per week moves through Rocky Mount and Wilson. One train per day serves the C.P.L. plants at Roxboro north of Durham (C.P.L.,1980; S.C.L.,1980; A.O.V., 1980). On the average the 24 million annual tons of coal shipped to North Carolina power plants must be carried by the equivalent of five or six unit trains per day. Including the returning empty cars, this means that the central and western parts of North Carolina are presently experiencing the equivalent of 10 to 12 coal

train movements per day. This traffic is roughly half that expected for eastern North Carolina if the pending coal terminals for Radio Island and the Wilmington area are built.

2.2 Other Rail Traffic

In addition to the shipment of coal, other types of commodities are moved by rail in North Carolina. To provide a brief overview of the prospects for future growth of other types of commodity shipments and their potential impact on the state and the coastal study area rail system, a series of factors will be discussed: (1) annual tonnage by commodity type shipped by rail, (2) the origin and termination points of rail traffic by commodity type in the state, and (3) the projected growth of rail traffic by commodity type in the state. The focus is on rail shipments on the Seaboard Coast Line and the Southern Railroad, the principal rail carriers serving North Carolina and the coastal study area.

Using 1977 as a reference year, the last year for which data are available, the rail tonnage for the Seaboard Coast Line and the Southern Railroad by commodity type and the percentage of total tonnage are shown in Table 2-1. For both railroads, eight commodity groups accounted for 84 percent of the rail shipments. While coal is the leading commodity moved by both railroads, there is variation between the two railroads in the relative magnitudes of other commodity types.

For the Seaboard Coastline, chemicals (14.2%), lumber and wood products (12.9%) and pulp and paper products (11.5%) are the next three most important commodities after coal. For the Southern Railroad, stone, clay and glass products (10.6%), lumber and wood products (9.8%), and pulp and paper products (9.4%) are the next three most important commodities after coal.

While significant, the data on total commodity rail shipments do not reveal their full impact on North Carolina's economy. Also important is whether rail freight originates or terminates in North Carolina, since the commodities originating or terminating imply jobs for North Carolina residents. As seen in Table 2-2, the Seaboard Coast Line is more likely

TABLE 2-1 Tonnage and Percent of Total Tonnage Shipped By Seaboard Coast Line and Southern Railways, 1980.

Commodity	SCL		Southern	
	Tons (000s)	Percent	Tons (000s)	Percent
Farm products	989.3	2.5	2,281.3	6.1
Coal	8,764.6	22.6	11,261.4	30.1
Chemicals	5,491.1	14.2	2,474.5	6.6
Lumber, wood products	4,991.1	12.9	3,644.8	9.8
Pulp, paper, allied products	4,447.7	11.5	3,525.8	9.4
Food, kindred products	3,113.8	8.0	2,647.0	7.1
Stone, clay, kindred products	2,699.5	6.9	3,949.0	10.6
Nonmetallic minerals	2,757.3	7.1	1,664.2	4.5
Other	5,554.9	14.3	5,885.5	15.8
Total	38,817.1	100.1	37,369.0	100.0

Source: N.C. Department of Transportation, North Carolina Rail Plan, 1979. Raleigh, North Carolina.

TABLE 2-2 Rail Shipments Originating, Terminating, and Through Traffic by Commodity Type, 1977.

Commodity	SCL				SOUTHERN			
	Originating With Company (000s)	Terminating With Company (000s)	Through Traffic (000s)	Total (000s)	Originating With Company (000s)	Terminating With Company (000s)	Through Traffic (000s)	Total (000s)
Farm Products	276.4	467.7	245.2	989.3	51.4	1,379.3	850.8	2,281.3
Coal	4.0	4,334.5	4,426.1	8,746.0	3.3	8,046.9	3,211.2	11,261.4
Chemicals, allied products	1,627.7	2,039.5	1,824.0	5,491.4	111.3	1,356.8	1,006.4	2,474.5
Lumber, wood products	3,259.2	2,357.9	-	4,991.1	834.6	2,166.5	643.6	3,644.8
Pulp, paper products	870.6	345.9	3,231.3	4,447.7	510.5	765.5	2,249.9	3,525.8
Food, kindred products	571.8	1,099.8	1,442.2	3,113.8	570.2	1,377.7	699.1	2,647.0
Stone, clay products	449.1	994.7	1,255.8	2,699.5	503.3	1,110.4	2,335.2	3,949.0
Nonmetallic minerals	1,144.6	865.3	747.4	2,753.3	291.6	434.0	938.6	1,664.2
Other	935.9	4,225.4	2,918.7	5,554.9	1,629.6	1,186.2	-	5,885.5
Total	9,139.3	16,730.7	16,090.7	38,817.1	4,505.8	17,823.3	15,039.8	37,690.0

Source: N.C. Department of Transportation, North Carolina Rail Plan, 1979. Raleigh, North Carolina

to have commodity shipments originating in the state. Of particular importance are originating shipments of lumber and wood products, chemicals, and nonmetallic minerals. These shipments are tied to the state's forestry, chemical, and mining industries. For example in eastern North Carolina, the shipments of nonmetallic minerals and chemicals is tied to the Texas Gulf mining operation in Beaufort County. Importantly any growth in rail shipments of commodities originating in North Carolina would imply increased demand for the state's resources and more jobs than if the commodities had originated out of state.

The prospects for future increases in rail shipment of commodities depends on increased market demand for the specific commodity and whether customers will continue to ship by rail or seek the development of alternative modes of transportation. Using trend data, the North Carolina Department of Transportation has projected growth in rail tonnage by commodity type through the year 1992. The figures presented in Table 2-3 represent projections for all Class I railroads so that the potential for growth in rail service in the coastal study area can only be inferred. For the commodities other than coal, the state projections forecast increases in shipments of lumber and wood products, chemicals, pulp and paper products, stone products and food products. Decreased shipments of nonmetallic minerals and farm products are projected by the year 1992, trends which indicated that producers will increase use of modes of transport other than rail.

A conclusion drawn from the data is that rail traffic in North Carolina is projected to increase during the 1980's and by inference rail traffic in the coastal plain will also increase. The types of commodity which will be the source of growth will have an impact on the job market on North Carolina. For example, growth in lumber products or chemicals originating or terminating in North Carolina implies increased employment opportunities for residents.

TABLE 2-3 RAILROAD COMMODITY PROJECTIONS, NORTH CAROLINA, 1967-1992.

COMMODITY	ANNUAL TONNAGE CARRIED BY RAIL						
	Historical Carriage				Projected Carriage		
	1967	1972	1976	1977	1982	1987	1992
	(In thousands)						
Coal	37,278	34,952	36,742	40,853	51,350	55,178	59,000
Lumber & wood prods.	9,504	10,724	9,908	9,748	9,900	10,000	10,100
Chemicals & allied prods.	7,285	9,352	9,571	9,463	9,900	10,300	10,700
Pulp & paper prods.	7,936	8,810	9,004	9,256	10,000	10,600	11,400
Stone, clay, glass & concrete prods.	9,276	10,322	8,430	8,924	9,600	10,400	11,100
Food & kindred prods.	6,048	6,774	7,062	6,769	7,100	7,400	7,600
Nonmetallic minerals except fuels	10,726	9,325	6,556	5,925	4,600	3,300	2,000
Farm products	5,261	4,466	4,767	3,976	3,600	3,400	3,100
All other commodities and LCL traffic	12,527	13,945	11,327	15 786	17,700	19,600	21,500
TOTAL TONS	105,841	108,670	103,367	110,700	123,750	130,178	136,500

SOURCE: N. C. Department of Transportation, North Carolina Rail Plan, 1979. Raleigh, North Carolina.

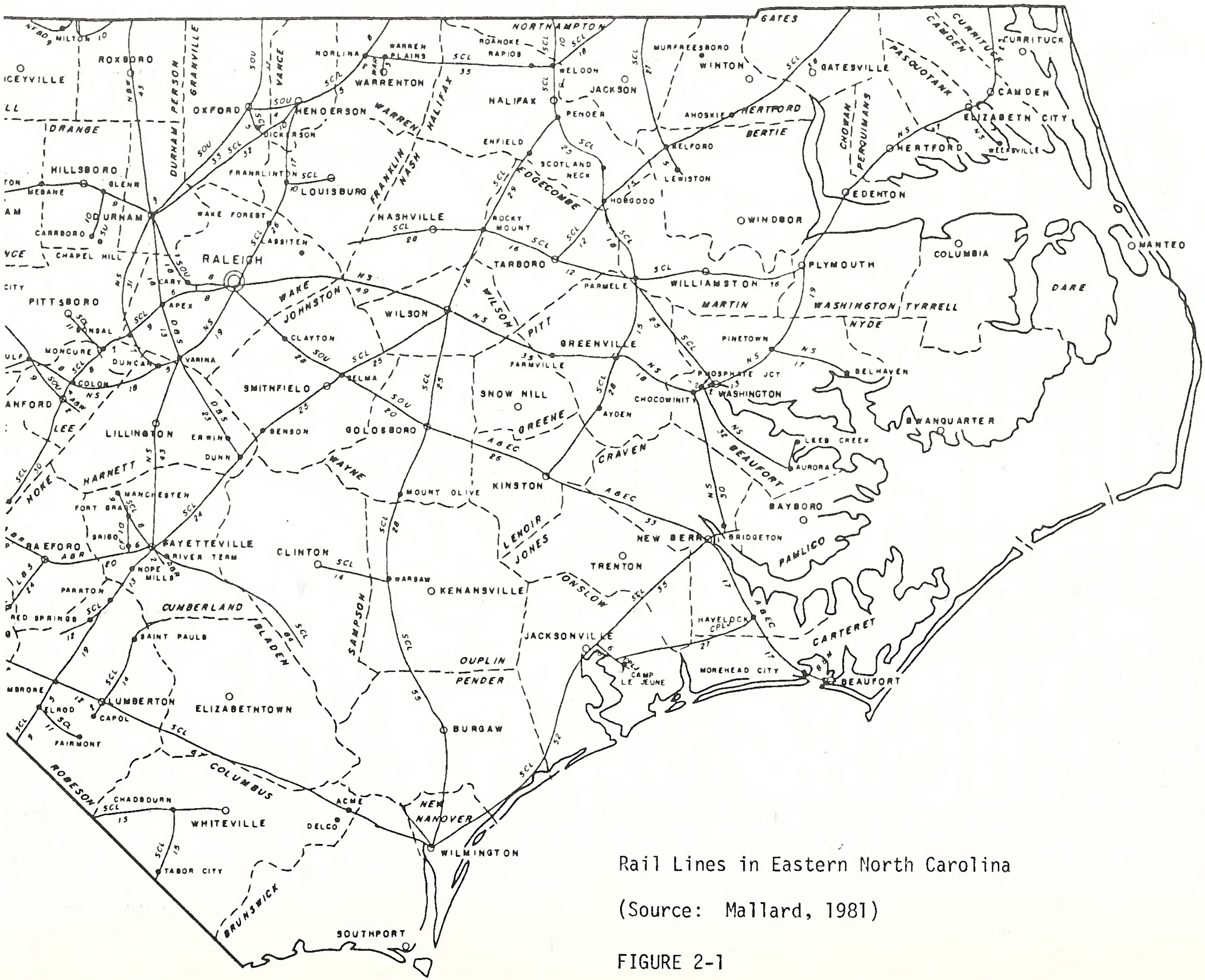
2.3 Rail Corridors

As can be seen in Figure 2-1, there are many rail lines throughout eastern North Carolina. The heaviest travelled mainlines (Class A, 20 million or more gross tons per mile per year) are the Seaboard Coast Line routes that come from Virginia through Rocky Mount, Wilson, and Fayetteville to South Carolina; and from South Carolina through Monroe, Laurinburg, and Lumberton to Wilmington. The Southern Railroad and Atlantic and East Carolina routes from Selma to Goldsboro, Kinston, and New Bern are also Class A mainlines. Class B mainlines (between 5 and 20 million gross tons per mile per year) run from Wilson to Wilmington (Seaboard Coast Line), Wilson to Chocowinity (Norfolk Southern), and Norfolk, Virginia to Chocowinity (Norfolk Southern). The remainder of the rail lines in Figure 2-1 are branch lines.

Because of the State interest in port and industrial development in eastern North Carolina, the rail corridors for analysis will be chosen as those which lead to the state ports in Morehead City and Wilmington. To reach the ports there are several alternative rail routes (Figure 2-2). Using coal trains as an example, all traffic bound for Morehead City must pass through the business districts of Morehead City and New Bern. West of New Bern the coal can follow either of two Southern Railroad routes: one through Greensboro, Raleigh, Wilson, and Greenville; or one through Greensboro, Raleigh, Goldsboro, and Kinston. West of Greensboro the route splits again depending on whether the coal comes from Virginia or Tennessee.

Coal bound for Wilmington has two route alternatives. If the coal comes from Virginia, it will follow the Seaboard Coast Line through Rocky Mount, Wilson, and Goldsboro to Wilmington. If the coal comes from Tennessee, it will follow the Seaboard Coast Line through Marion, Charlotte, and Lumberton to Wilmington.

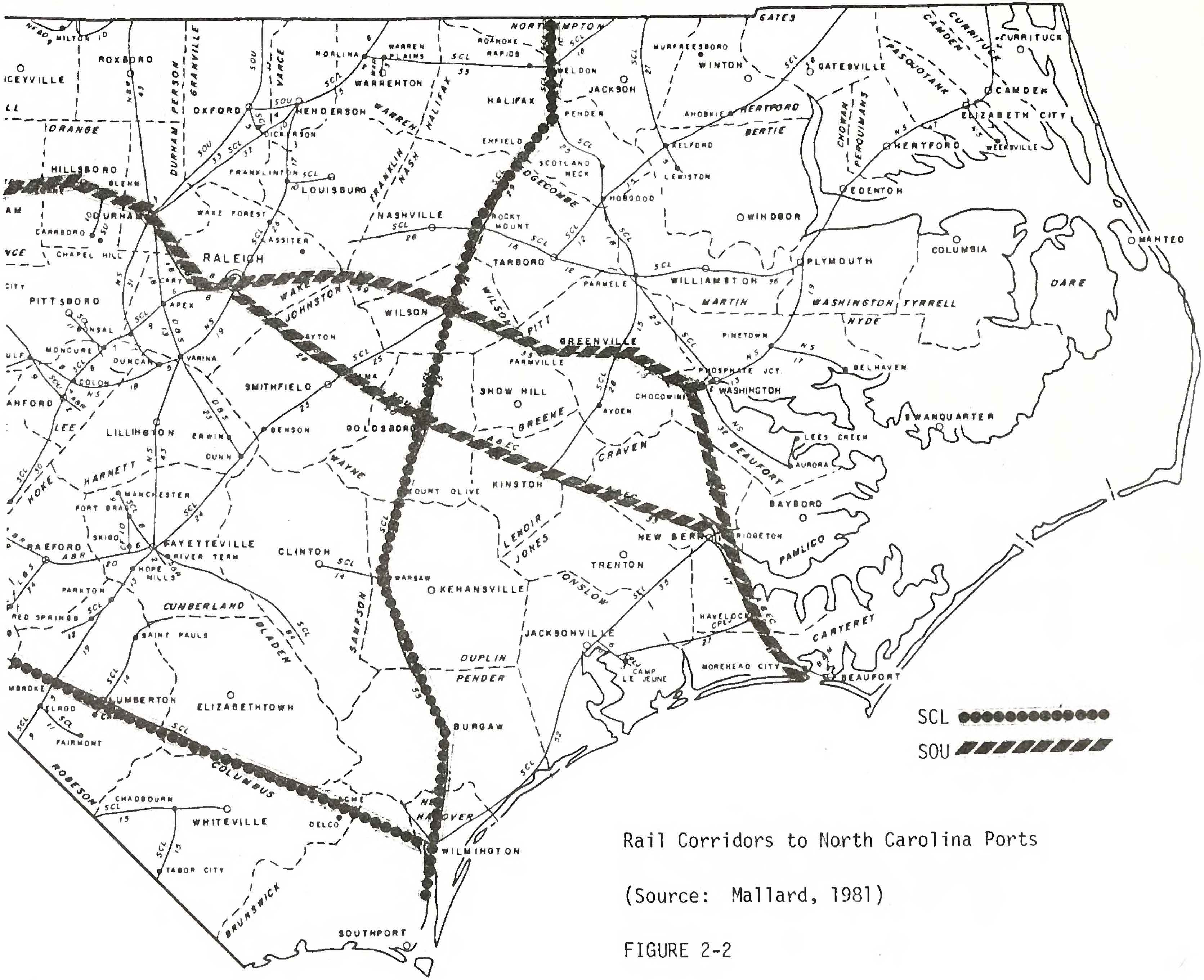
Other major commodity movements to the ports would likely follow the same or similar routes depending on their origins. Hence, the case study communities to analyze for railroad impacts from increased traffic will be chosen from the corridors leading to the state ports. These corridors cross 15 counties (Table 2-4) and include 224 rural crossings and 345 crossings in large and small communities.



Rail Lines in Eastern North Carolina

(Source: Mallard, 1981)

FIGURE 2-1



Rail Corridors to North Carolina Ports

(Source: Mallard, 1981)

FIGURE 2-2

TABLE 2-4

Eastern North Carolina Grade Crossings
in Primary Railroad Corridors to the State Ports

Location	Crossings	Railroad
Northampton		
Rural	6	SCL
Halifax		
Rural	3	SCL
Enfield	6	SCL
Weldon	8	SCL
Nash		
Rural	4	SCL
Rocky Mt.	8	SCL
Sharpsburg	3	SCL
Battleboro	2	SCL
Whitaker	5	SCL
Wilson		
Rural	9	SCL
	19	NS*
Wilson	8	SCL
	10	NS
Elm City	4	SCL
Black	3	SCL
Stantonsburg	3	NS
Pitt		
Rural	19	NS
Greenville	15	NS
Farmville	5	NS
Beaufort		
Rural	5	NS
Craven		
Rural	34	SOU
New Bern	15	SOU(NS)
Vanceboro	6	NS
Riverdale	3	SOU
Croatan	2	SOU
James City-Grantham	4	SOU
Dover	5	SOU

Location	Crossings	Railroad
Greene		
Rural	9	NS
Wayne		
Rural	13	SOU
	20	SCL
Goldsboro	19	SOU
	10	SCL
Mt. Olive	10	SCL
Pikesville	6	SCL
Fremont	9	SCL
Lenoir		
Rural	13	SOU
Kinston	22	SOU
LaGrange	9	SOU
Carteret		
Rural	7	SOU
Morehead City	38	SOU
Radio Island	4	SOU
Newport	5	SOU
Duplin		
Rural	21	SCL
Warsaw	8	SCL
Wallace	8	SCL
Magnolia	4	SCL
Teachey	3	SCL
Rose Hill	4	SCL
Calypso	5	SCL
Pender		
Rural	12	SCL
Burgaw	10	SCL
New Hanover		
Rural	14	SCL
Wilmington	31	SCL
Brunswick		
Rural	11	SCL
	5	U.S. Army
Boiling Spring Lakes	3	U.S. Army

*Norfolk-Southern (now called Carolina and North Western) is a division of Southern Railway, which merged with Norfolk and Western in June 1982 to become Norfolk and Southern Corporation.

2.4 Affected Communities

Considering the rail corridors which lead to the two ports, at least 36 communities (Table 2-4) with a combined population of about 300,000 will be affected. Table 2-5 shows those areas with individual populations greater than 1000. In order to assess potential impacts for a broad cross section of communities, 10 large and small communities on each rail corridor were selected. The case study communities on the Seaboard Coast Line corridor are Rocky Mount, Wilson, Goldsboro, Warsaw, Boiling Spring Lakes, and Wilmington. The Southern Railway corridor communities are Wilson, Goldsboro, Kinston, Greenville, New Bern, and Morehead City. Two cities, Wilson and Goldsboro, are at intersections of the rail corridors and could become major "hot spots" should railroad traffic increase in both corridors.

2.4.1 Rocky Mount

Rocky Mount is located on the "fall line" separating Piedmont and Coastal Plain North Carolina. It also straddles the line between Nash and Edgecombe Counties. Rocky Mount was originally founded as a mill town but in recent years the principal industry has become the warehousing, sale and processing of tobacco. It also serves as a regional shopping and trade center.

Transportation has had a marked influence on the location and physical characteristics of Rocky Mount. The original town was located near the Falls of the Tar River; the river providing an avenue of transportation and a later source of power. With the completion of the Wilmington and Weldon Railway the town moved eastward and developed along the tracks. The railroad (now the Seaboard Coast Line) still bisects the town and the main business street which has 10 at-grade crossings. In all there are 37 grade-crossings in the city. There are many crossings because there are extensive switching yards, terminals, and shops for the S.C.L. just south of the business area (Figure 2-3).

Rocky Mount is in transition from a rural to an urban area. This is evidenced by the fact that the city has been increasing in population while both Nash and Edgecombe Counties have lost population or have had

TABLE 2-5

Selected North Carolina Communities
on Major Rail-to-Port Corridors

Community	Population (1980 census)
Weldon	1,844
Enfield	2,995
Rocky Mount*	41,283
Wilson*	34,424
Goldsboro*	31,871
Mount Olive	4,876
Warsaw*	2,910
Burgaw	1,586
Wilmington*	44,000
Lumberton	28,340
Boiling Spring Lakes*	998
Greenville*	35,360
New Bern*	14,557
Havelock	17,718
Kinston*	25,234
Morehead City*	4,359
TOTAL	282,355

*Case Study Communities

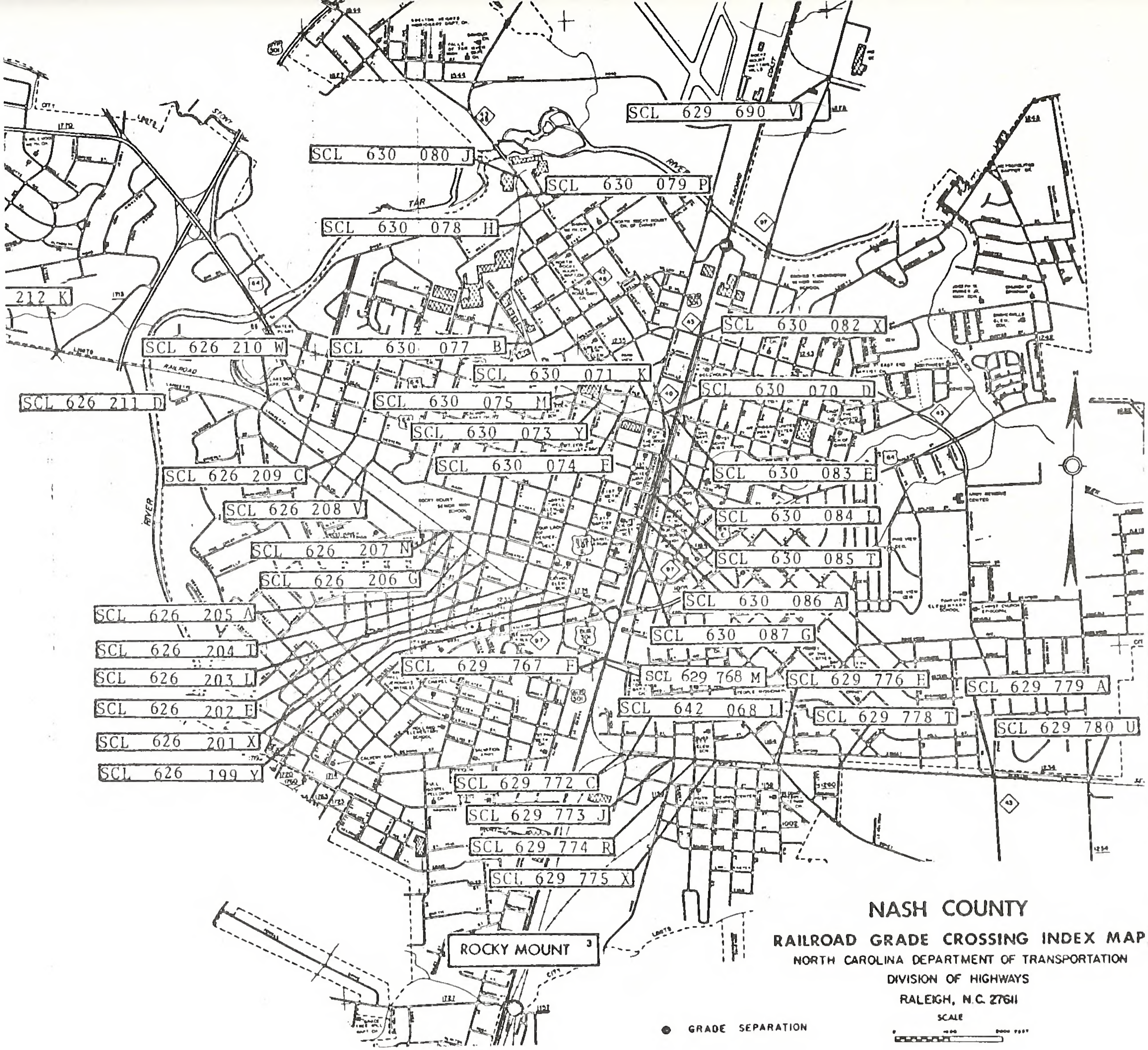


FIGURE 2-3 Rocky Mount

smaller increases in recent years. The current population is 41,283 and it is expected to grow to 46,000 by 1985. The greatest population increase has been in the western neighborhoods away from the railroad corridor. This trend will probably continue.

Public services within the city include Nash County Hospital, Stony Creek Rescue Squad, and four fire stations. In addition, two new fire stations are being planned. Since fire stations are located throughout the city, train delays have not been a major problem to primary responders. Secondary units are more likely to be delayed since they usually must cross the tracks. Only one delay has been recorded in the last 2 to 3 years. Route diversions are not recorded. The fire department has a "pre-emption box" which tells when trains are traveling through the city.

Medical emergency delays are more frequent but detailed information is unavailable. While fire fighters are full-time paid personnel, medical emergency personnel are paid during normal work hours and then volunteers take over at night and on weekends. Nearly all live on the same side of the track as the rescue squad, so they are not delayed by a train in reaching the squad building. The ambulance may, however, be delayed during its response to the emergency scene and to the hospital.

2.4.2 Wilson

The City of Wilson is located in the north central portion of the fertile North Carolina Inner Coastal Plain. It was incorporated as the Town of Wilson in 1849 from two railroad villages: Toisnot Depot and Hickory Grove. Then, as now, it sits astride the Seaboard Coast Line Railroad and is an important agricultural marketing center (Figure 2-4). Non-durable manufacturing is the fastest growth industry; though the City is most widely known as the Nation's largest bright leaf tobacco market.

The 1980 census showed 34,424 persons living in Wilson, and population may grow to 36,386 by 1987. The majority of this growth will occur in the western quadrants of the city which are formed by the intersection of the Carolina and Northwestern Railway (a subsidiary of Southern Railway and previously called the Norfolk and Southern Railway), and the Seaboard Coast Line.

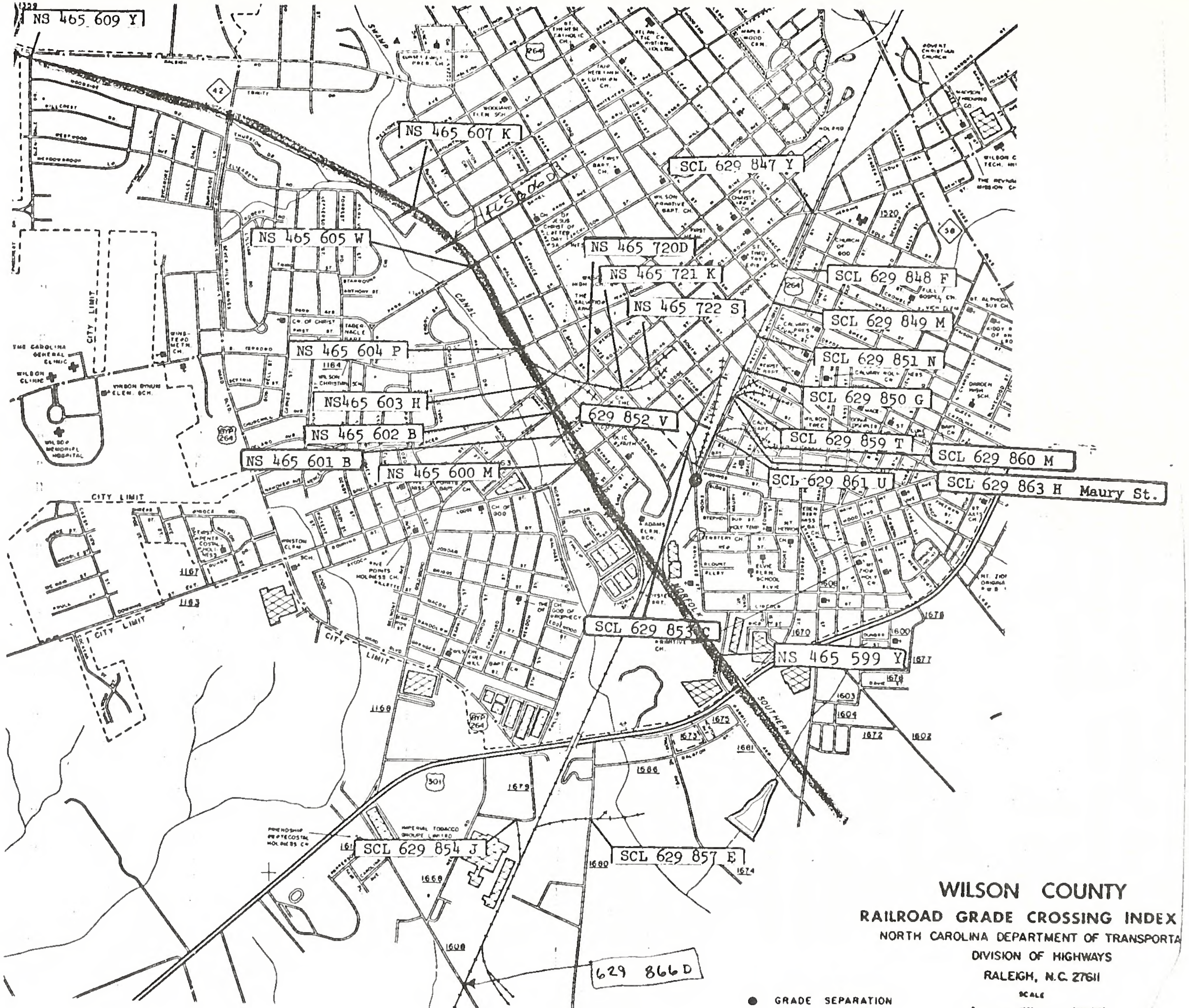


FIGURE 2-4 Wilson

Because Wilson is built around the intersection of two major rail corridors, there is the potential for substantial rail/community conflicts if rail traffic increases in both corridors. There are 20 at-grade rail crossings, 12 of which occur at streets which carry more than 2000 vehicles daily. The Carolina and Northwestern (Southern) traffic has on the average two trains per day, and SCL daily train movements average 25 to 30.

2.4.3 Goldsboro

Before the mid 1950's, Goldsboro was an agriculturally oriented city. In 1956, Seymour Johnson Air Force Base was reactivated immediately south of Goldsboro. This caused a sudden change in employment and population characteristics by attracting military, industrial and commercial expansion. Population currently stands at about 32,000.

From the standpoint of railroad operations, Goldsboro is very interesting because it lies at a junction of the SCL and Southern railroads (Figure 2-5). Presently four train movements pass through the city daily. This may rise to six in five years due to normal growth or as many as 30 if high volumes of coal or other commodities begin to flow to Morehead City and Wilmington. Like Wilson, Goldsboro could become a railroad "hot spot" depending on how much freight is shipped by SCL and Southern and depending on the routes chosen.

2.4.4 Warsaw

Warsaw, a town of 2910, is located in the west-central section of Duplin County. U.S. Highway 117 and NC highways 50 and 24 run through the town as does Seaboard Coast Line Railroad (Figure 2-6). One rail line travels from Clinton east into Warsaw and intersects with the main SCL line that leads to Wilmington. The north-south line runs parallel to U.S. 117 but crosses NC 24.

The most densely populated areas in Warsaw are within three or four blocks of the train depot which closed down in early 1982. Population is expected in increase by 6.5% during the next five years so that a population of 3,100 is predicted for 1987.

FIGURE 2-5 Goldsboro

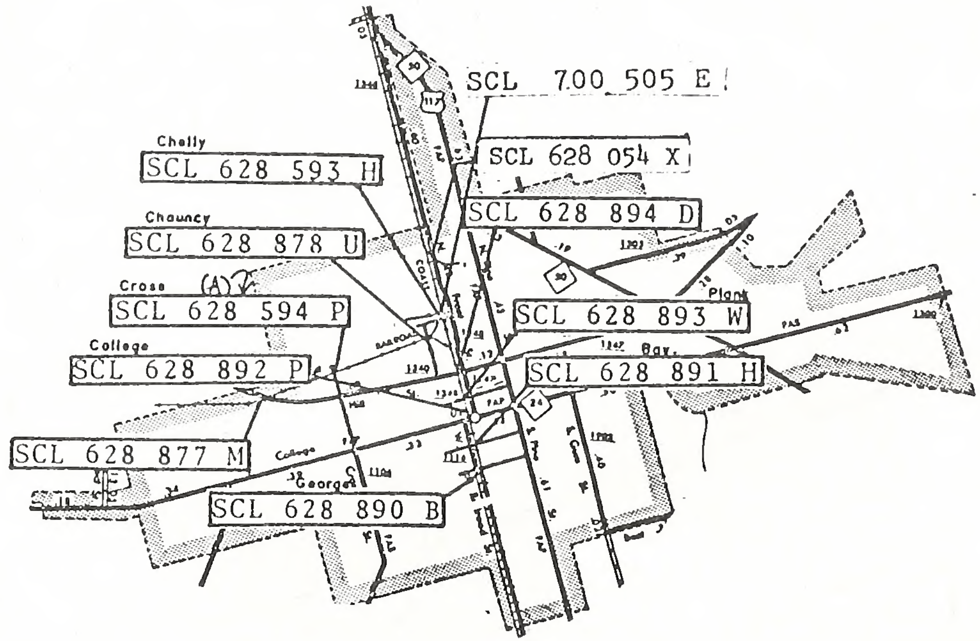


FIGURE 2-6 Warsaw

The Central Business District is basically located between the rail line and U.S. 117. There are eight at-grade crossings in this area. Warsaw is served by Duplin General Hospital located 8 miles southwest of Warsaw in Kenansville and by Sampson Memorial Hospital in Clinton, 12 miles away. NC 24 serves as the main route to both hospitals. Police, ambulance, and fire services are located on Bay Street at the southern end of the business district.

An average of two trains pass through Warsaw daily. Town ordinances forbid trains to stand at a crossing for more than five minutes or to operate at speeds in excess of 35 mph.

2.4.5 Wilmington

Wilmington is one of the two major seaports serving the State of North Carolina. Located on the Cape Fear River, it serves as the principal urban area in southeastern North Carolina. Wilmington's picturesque seacoast location and fascinating historical background attract many summer residents and retirees to the area.

Wilmington is also attractive to business, industry, and commerce because of its rail connections, port facilities, and access to the Atlantic Ocean via the Cape Fear River. For these reasons, two terminals have been proposed for Wilmington. One would have been located on the downtown waterfront and one at the State Port south of the city (Figure 2-7). In June 1982, the voters of Wilmington voted against the downtown location and it is unlikely that one will ever be built there. The proposed terminal at the State Port is also "iffy". The interested company has indefinitely delayed its plans for development. Public opposition has also been raised against this proposal. It would divide the city and bring noise, vibration, and lower property values according to a recent report (Anderson and Associates, 1982). Unfortunately these disadvantages would not be offset by substantial numbers of permanent new jobs or increased tax collections according to the report.

Regardless of the future developments in coal, Wilmington and its surrounding area will continue to grow. The current population is about 44,000. This population is served by many public services: Five fire

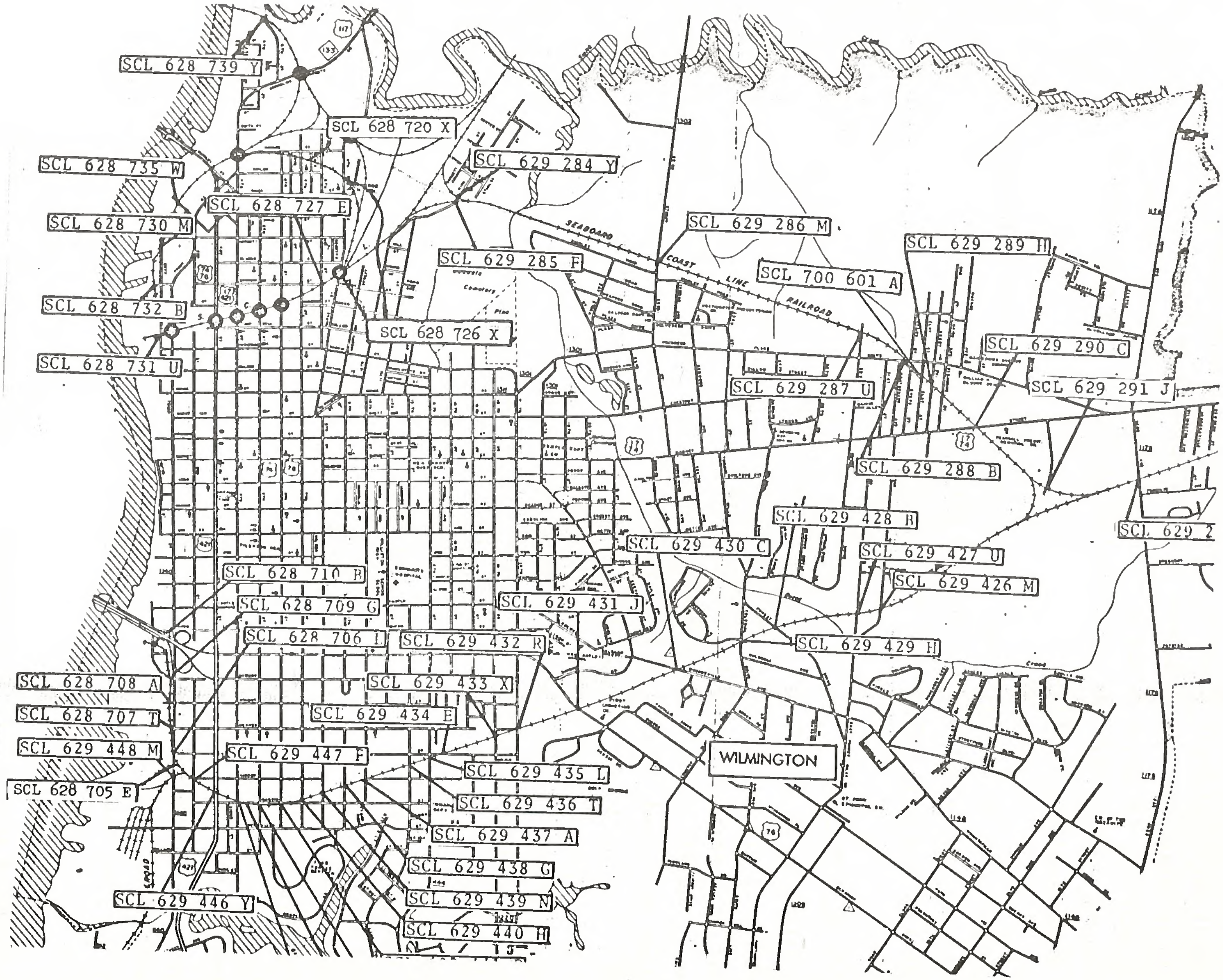


FIGURE 2-7 Wilmington

stations, six rescue squads, the sheriff and police department. Potentially, the responses of all of these services can be affected by train traffic. The two area hospitals which receive emergency medical cases are the New Hanover Medical Hospital and Cape Fear Memorial Hospital.

Wilmington has 60 at-grade crossings within its city limits and an additional 31 in the immediate area. Of the 73 crossings, 15 occur on the seven-mile loop track which serves the state port. Currently one daily train travels this loop; perhaps 10 or more train movements would occur if coal or other bulk commodities were to be exported from the state port in large volumes.

2.4.6 Boiling Spring Lakes

Boiling Spring Lakes is a small town of 998 people located north of Southport in Brunswick County. Predictions indicate that the population will increase to 1,500 by 1987, and population distribution with respect to the railroad will tend to remain the same (80% west of the railroad). The town has developed around Boiling Spring Lakes which has become a tourist attraction because of its limestone basin. NC Highway 87 runs through town bringing many tourists and vacationers as it is a major thoroughfare to the North Carolina coastal area. (Figure 2-8).

The town center extends along both sides of NC 87 in the center of town. Other commercial areas are also located along NC 87 but extend further north and south. The rescue squad, fire department, and police department are all located in the town center. The closest hospital is located in Southport, approximately six miles away. Highway 87 and 133 are main routes to the hospital from the town.

The Sunny Point Railroad, which is owned by the federal government, passes through the town enroute to Sunny Point Army Terminal located south of Boiling Spring Lakes. The tracks run within 50 yards of the Boiling Spring Lake. There are three at-grade crossings in Boiling Spring Lakes. Currently, three to four round trips are made daily by trains with an average of six cars. These trains travel at approximately 5 mph through town. Train movement usually occurs in the early to mid-morning and again in late afternoon.

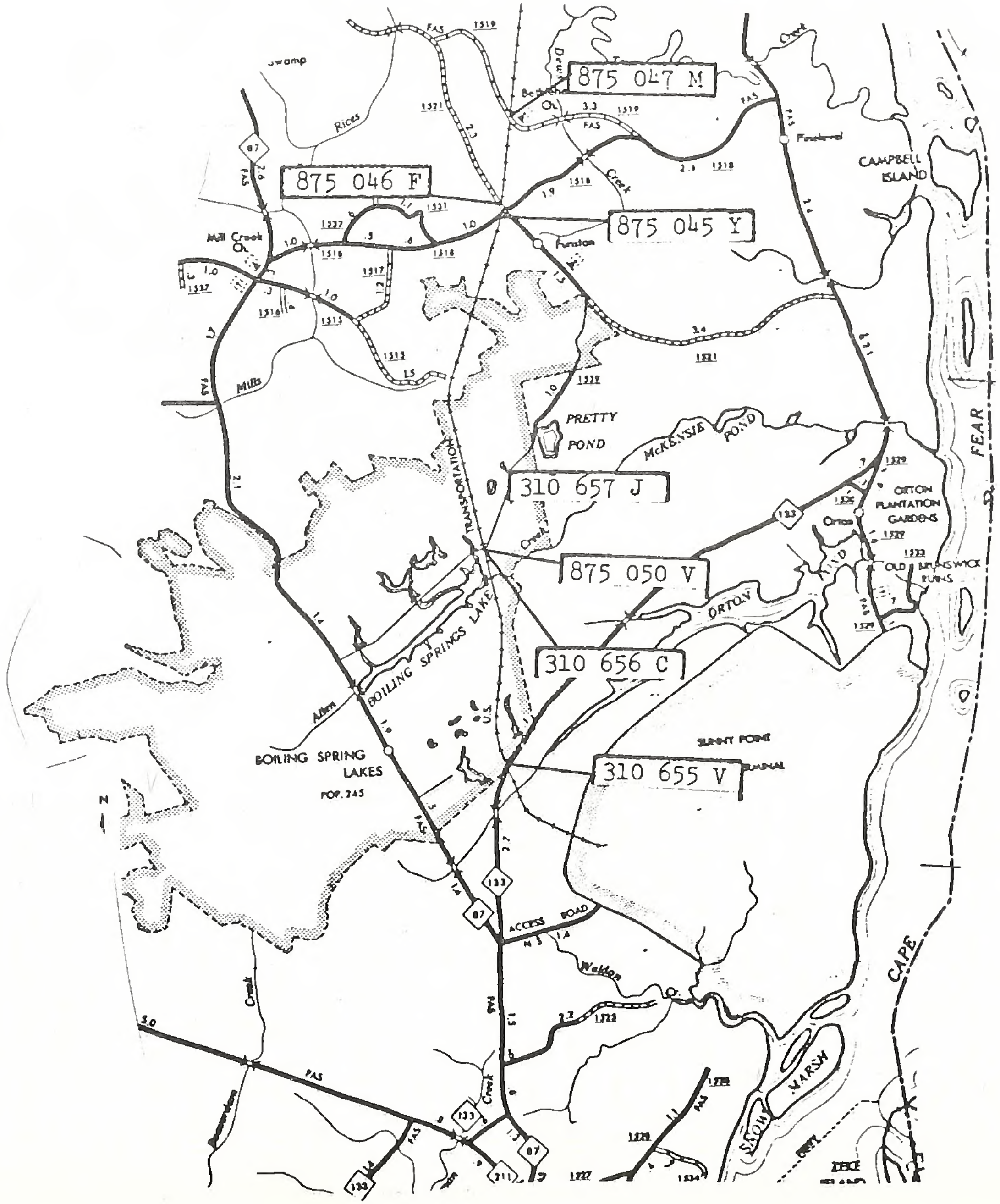


FIGURE 2-8 Boiling Spring Lakes

2.4.7 Greenville

Greenville, with a population of 35,360, is located in Pitt County (Figure 2-9). Norfolk Southern Railway intersects the Seaboard Coast Line Railway near the center of the city. A large percentage of the population resides in the central and southern areas of the town.

The central business district extends from the Tar River south to Reade Circle. Also included in the CBD are the Pitt County Courthouse, City Hall/Police Station, and a fire station with emergency medical team (EMT). Two additional fire stations are located inside the city limits, one on either side of the Seaboard Coast Line in the southern part of Greenville. One station also has an EMT.

There are 16 at-grade railroad crossings on Greenville's streets, none of which are in the CBD. Eight city streets cross the Seaboard tracks and eight cross the Southern tracks. Extensive switching yards are located in the northern industrial area. All crossings involve one main track and two lanes of traffic with three exceptions. Fourteenth Street, Arlington Boulevard, and Elm Street are all classified as arterials and have four lanes of traffic. Average daily traffic (ADT) on the two-lane streets ranges from 2,000 to 5,500 vehicles. ADT for the four-lane streets ranges from 5,000 to 8,500 vehicles. Seaboard averages a minimum of two to four through trains daily. This movement results in six to ten minute delays at crossings. Southern Railroad movements average four per day and delay traffic no longer than ten minutes at crossings.

City ordinances regulate some train movement. These ordinances include the following:

1. The train's bell must be rung while passing through the city,
2. Trains may not stop across a street for longer than 10 minutes,
3. Railroad companies must provide proper warning devices at all street crossings, and
4. Trains may not operate in excess of 35 mph within the corporate city limits.

FIGURE 2-9 Greenville

2.4.8. New Bern

The City of New Bern, population 14,557, is located in Craven County. It is bounded on the north by the Neuse River and on the east and south by the Trent River (Figure 2-10). Once the colonial capital of North Carolina, New Bern now attracts tourists to its Historical District where at least six of the buildings located along Hancock Street are listed in the National Historic Registry.

U.S. Highways 70 and 17 as well as NC 55 are the major roads in New Bern. Several railroad lines also traverse the town including the Atlantic and East Carolina Railroad, the Seabord Coast Line Railroad, and the Norfolk Southern Railway. Intersections of the railroads are located north of the Historical District, as is the switch yard. The Atlantic and East Carolina Railway crosses NC 55 inside New Bern city limits, and the Seaboard Coast Line Railroad crosses U.S.17 outside the city limits. All crossings are at-grade.

The Central Business District, which includes the Historical District, extends from the riverfront to Eden Street. The Atlantic and East Carolina Railway runs through the CBD along Hancock Street. Other commercial areas are shopping centers and businesses in outlying areas adjacent to Highways 17 and 55.

Public services include four fire stations - #1 is located just outside the north boundary of the CBD, #2 at National and North Avenues, #3 off Fort Totten Drive, and #4 at Glenburnie Road at Elizabeth Avenue. The Craven County Hospital is located on Neuse Boulevard (NC55) while Johnson Memorial Hospital is located closer to the CBD off Queen Street.

Residential areas surround all three railroad lines; however, the most densely populated areas are located between the tracks of the Atlantic and East Carolina Railroad and the Seaboard Coast Line Railroad. Because New Bern is bounded on the north, east, and south by rivers, major population growth will occur in the western area of the city.

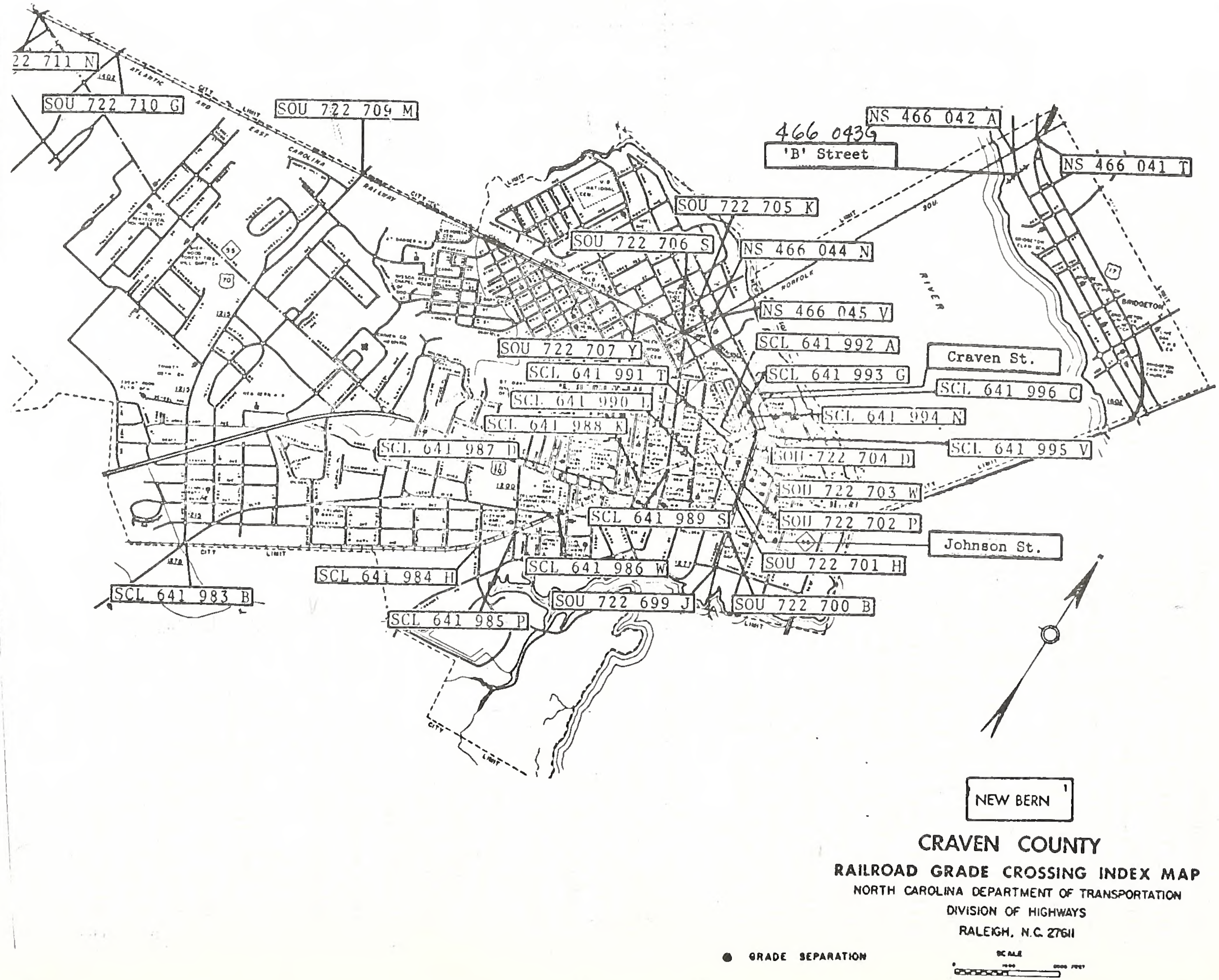


FIGURE 2-10 New Bern

There are seven at-grade crossings on the Norfolk Railway and Atlantic and East Carolina Railway adjacent to the CBD. All crossings have one main track and two traffic lanes.

Currently, an average of six daily trains with up to 145 cars each pass through the community. A speed of 5 miles per hour (mph) was required by old city ordinances; however, new ordinances will allow speeds of 10 mph through town. Coal trains move through New Bern's CBD in route to the State Port Authority coal terminal at Morehead City. The initial two-week coal train pattern was 7-8 a.m. coming with a return at 11-12 p.m. Following this two-week period, the pattern became more sporadic. No coal trains passed through the community between December, 1981 and April, 1982. They have since resumed.

Non-coal trains traveling east pass through the city every two hours from 5 p.m. to 11 p.m.; west bound trains, at 12 and 1:30 a.m. North bound trains traverse the area at 8 a.m. and 5 p.m. Train switching occurs throughout the night and air brake tests are conducted once trains have been hooked-up and are enroute.

City officials are most concerned with traffic blockage in the CBD where the Atlantic and East Carolina Railway line runs down Hancock Street in the historic district. All crossings in this area are blocked when a train passes.

2.4.9 Kinston

Kinston is a city of 25,234 people located in Lenoir County. The Neuse River forms the city limits on the western and southern sides of the city (Figure 2-11). A Southern Railroad line runs from Goldsboro through Kinston on its way to New Bern. A Seaboard Coast Line Railroad runs south from central North Carolina and intersects the Southern Railroad.

The CBD runs from the Neuse River east to East Street and from Capitola Street south to Lincoln Street. The Southern Railroad line bisects the CBD and then intersects with the Seaboard line just east of the CBD.

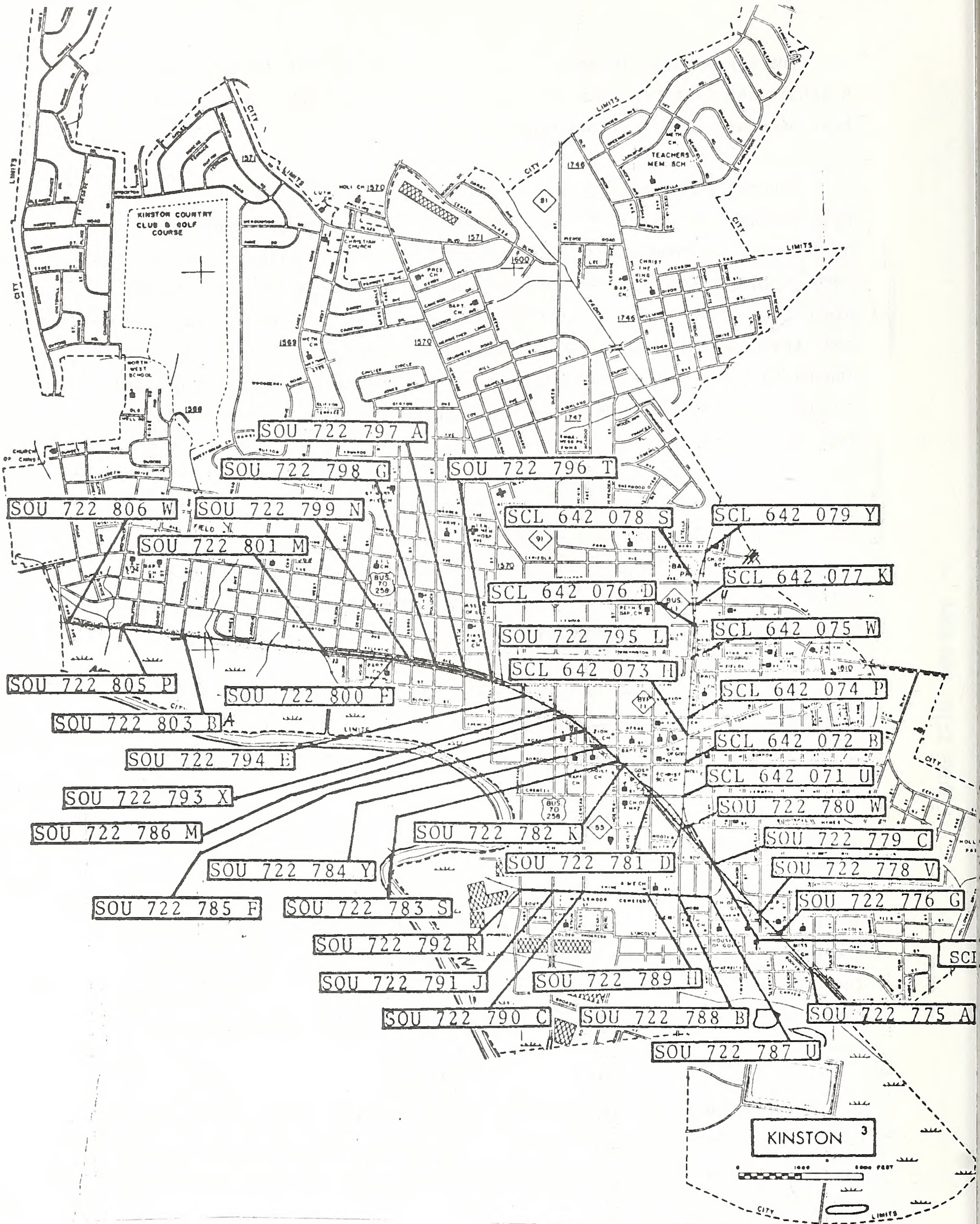


FIGURE 2-11 Kinston

Major community facilities include a Central Fire Station and City Hall located on King Street in the CBD and three other fire stations - one in southeastern Kinston outside the CBD, a second in northern Kinston, and the third in western Kinston. During the past years, 60% of inter-city emergency calls have come from the southeastern portion of the city.

Lenoir Memorial Hospital is located in the far north section of Kinston with Queen Street being the main north/south route. Queen Street is crossed by the Southern rail line inside the CBD. Two additional clinics are located in the central and northern sections of Kinston. Kinston has not experienced problems in emergency vehicle delays at train crossings because train lengths have actually been short, and alternate routes have been available.

An average of two or less trains come through Kinston daily at speeds ranging from 5 to 15 miles per hour. These trains, with lengths of 5 to 20 cars, run at irregular hours so that the associated operations go on virtually unnoticed. At present, city officials expect little change in the number and frequency of train movement during the next five years. This expectation will prove erroneous if Southern switches its coal movement from the Greenville-Chocowinity route to New Bern to that through Goldsboro and Kinston.

2.4.10. Morehead City

North Carolina's Carteret County contains the neighboring areas of Morehead City, Beaufort, and Atlantic Beach, which comprise an exceptional coastline community. The area is primarily a summertime vacation area with a major portion of the area income coming from recreational and retirement interests. Shipping, sport and commercial fishing, and boat building also contribute. Recently coal exporting has played a role in the area's economy along with the existing bulk shipments of phosphate.

In order for the coal to reach the existing terminal at the State Port Authority it must travel through the center of Morehead City,

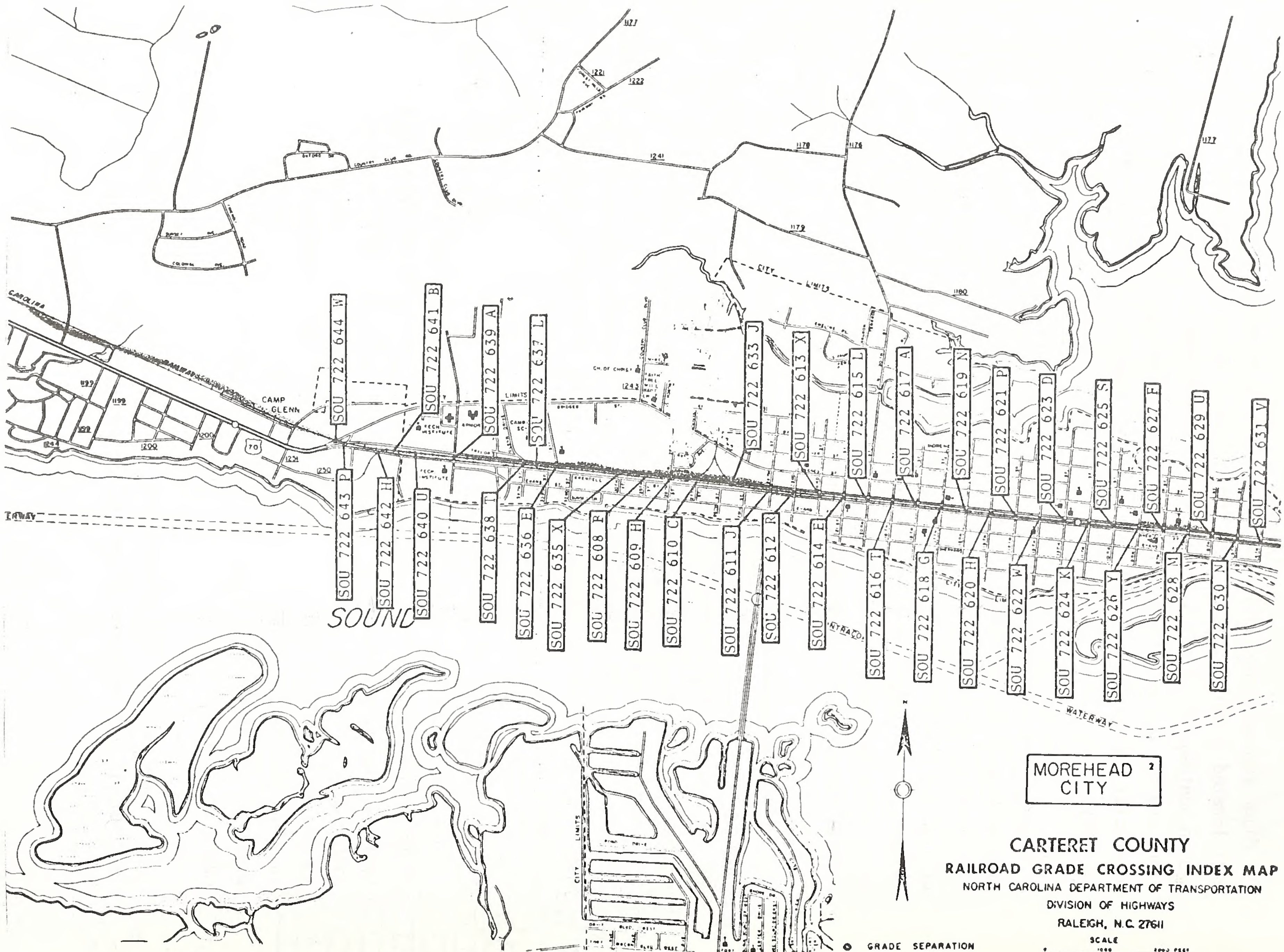
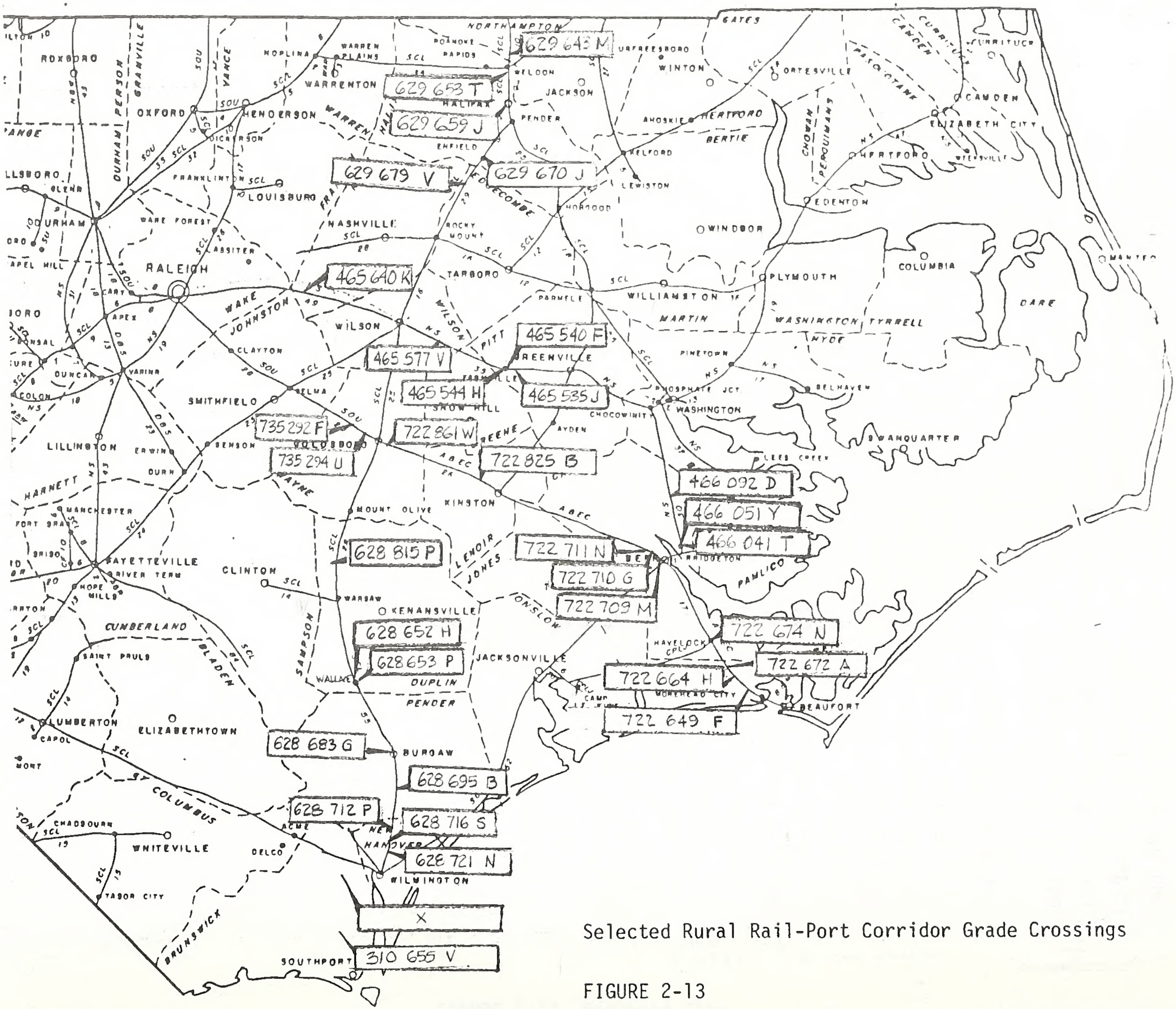


FIGURE 2-12 Morehead City

crossing 29 streets (Figure 2-12). Currently there are two non-coal train movements per day and coal trains to the S.P.A. terminal would add two more movements. For coal operations to expand to 20 MTA, six trains or twelve movements would be required. For them to travel through Morehead City is unacceptable according to state officials, and new rail corridors and a slurry pipeline are being studied (NCDOT, 1982).

2.5 Rural Crossings

Besides the rail crossing conflicts that can occur in communities, the same problems can occur in rural areas. In the 15 counties covered by this study, there are 224 rural crossings on railroad corridors leading to the ports. Of these, 34 have been identified as being potential problem spots based on the level of highway traffic being greater than 2000 vehicles per day. Figure 2-13 locates these crossings in the study area.



Selected Rural Rail-Port Corridor Grade Crossings

FIGURE 2-13

3.0 OPPORTUNITIES AND IMPACTS

Traditionally as the trade and commerce of a region increase, new economic oppertunities develop that benefit the region. New jobs and economic development can be generated by improved transportation. The situation will be no different as rail traffic to and from the State's ports increases. However, the majority of the beneficial economic impacts will occur at the origins and destinations of the rail shipments; not in the communities through which the rail shipments must pass. In this regard the localized and regional economic benefits must be carefully weighed against the negative rail/community conflicts that will occur from increased traffic disruptions, accidents, noise, vibration, and the like.

The following section explores the range of economic opportunities and possible negative impacts from increased rail traffic in eastern North Carolina. To illustrate how increased rail traffic to the ports can affect the region, increased coal train traffic possibilities will be examined. However, the results generally apply to any type of bulk commodity or freight shipments - agricultural products, minerals, etc.

3.1 Economic Opportunities

Economic benefits will accrue to both ports and inland areas as rail transportation increases. However, if the production of the commodity occurs outside North Carolina, it is doubtful that inland cities will receive any more than minimum economic gains resulting from the relatively few additions railroad jobs that are required for the additional trains. Only the port areas will benefit in a significant way as additional terminal facilities are built and staffed. This is particularly true if the commodity being shipped requires specialized, dedicated terminal facilities like coal or other minerals. Otherwise, if port facilities like container loading/unloading equipment, warehouses, and the like can be shared among commodities or products,

then economic development will migrate into the port region.

These economic development concepts are discussed with regard to coal in the following section.

3.1.1 Port Development

A number of economic impacts will accrue to the port area from coal export business. The primary impacts may be measured in terms of additional jobs, increased payroll, and increased tax revenues. Not only will the coal business generate these impacts, but also other non-coal-related businesses may be attracted or induced to expand by the improved rail and port facilities.

Businesses required by the coal operation will be the major benefactors. They provide the services necessary to move the coal and include such port activities as terminal operations, ship repair, stevedoring, and vessel supply. A variety of transportation services (primarily rail, but possibly truck, barge, conveyor, and slurry pipeline) are also necessary. Besides the industries required by the coal operation, some persons expect that coal exports will act as a magnet for attracting new industries. Others believe coal may frighten away some businesses, expecially those associated with existing vacation and retirement areas.

If new businesses are attracted, they may be exporters or importers that can utilize the improved port and rail linkages developed as a result of the coal operations. Existing mining, manufacturing, and agricultural industries in the region served by the port may also be induced to expand the boundaries of their markets if reduced transportation costs result from the coal-related rail and port improvement project. Such port-dependent industries are typically located at substantial distances from the port and may, therefore, help to spread the economic impact of coal port development beyond the immediate port area.

Secondary economic impacts also result from increased port operations (whether they relate to coal or other commodities) because of a

multiplier effect associated with port employment. A newly hired port employee, for example, will presumably spend a substantial portion of his or her pay check in the port community. This raises the income level of local businesses and allows them to expand, hire more employees who spend more money, and so forth. This economic "ripple" spreads throughout the community and is described by the multiplication of economic benefits beyond those related directly to new port activity. In most assessment methodologies, the magnitude of the multiplier effect is proportional to the employment level in the primary port-related industries. Therefore, it may be expected that the multiplier effect will be larger for labor-intensive port operations than for capital-intensive operations.

Special economic opportunities at ports also exist for joint government-private enterprise investments when new coal terminals and their rail links are built. Using the recent development of a coal terminal as an example, AOV Industries made capital improvements at their own expense to the state-owned port at Morehead City, and Southern Railroad improved the tracks and grade-crossings in Morehead City. The potential for additional cooperation among the state, railroads, and coal companies exists when grade-crossing, even rail bypass, improvements are needed elsewhere along the rail corridors leading to the ports. It may also be argued that the major financial responsibility for the rail and port improvements needed to mitigate adverse community impacts should be borne by the rail and coal companies if they stand to receive the majority of the economic benefits from coal or any other commodity shipment. And that indeed out-of-state rail and coal companies will profit substantially more than North Carolina from moving coal is supported by the following paragraphs.

Primary, secondary, and special economic impacts can be assessed with various economic tools. For example, the U.S. Department of Commerce has developed a methodology to estimate port economic benefits, and it has been applied to determine the economic impacts of the Port of Hampton Roads (Silberman, 1980; USDC, 1979).

The methodology determines the magnitudes of the economic benefits

resulting from all port activities in terms of the employment, payroll, and tax revenues associated with the primary and secondary impacts from industries required, attracted, or induced by the port. The specific impacts from coal have to be "broken out" and to these figures are added any private investments in state or city-owned facilities.

While the above methodology has not been applied to North Carolina port operations, certain general observations may be made based on the initial coal operations of AOV Industries in Morehead City, coal company estimates, and the impact analysis applied to Hampton Roads.

According to AOV, the company has spent $2.75 million with North Carolina businesses since mid-January, 1981. In the future, local business revenues should stabilize at the $1 million level assuming three million tons of coal are shipped annually from the Morehead City Terminal. Docking charges and the lease agreement should generate $3.7 million in revenues paid directly to the State Port Authority. No property tax revenues are paid since the terminal is on state-owned property. The AOV operation also created 79 full and part-time jobs, with an estimated payroll worth about $1.2 million during the eight months of full operation. While it is difficult to estimate an accurate multiplier effect, AOV used a multiplier of 3.0 to derive a total payroll benefit of $3.6 million to the Morehead City economy during 1981. As operations resume in 1982, the total annual payroll, including the multiplier effect, may reach $5.0 million according to AOV estimates (AOV, 1981; NCDNRCD, 1981).

Similar job and payroll impacts may be expected from other coal terminal operations. According to data available to NCDNRCD, proposed investments in North Carolina coal terminals may reach $310 million and employ 374 workers with an annual payroll of over $5 million (no multiplier effect included). Combined, these operations could ship 80-90 million tons annually from North Carolina. When these job, payroll, and tonnage figures are compared to the AOV figures, it is seen that as coal exports increase by a factor of 28, payroll and employment increase by only a factor of four. This results because coal operations are not labor-intensive. Thus, as the coal exports grow, positive economic impacts for the port community will tend to remain constant while negative impacts will increase with growing coal traffic.

The results of other studies provide points of comparison for the economic impacts related to jobs, payroll, and the multiplier effect discussed above. In his study of the economic impacts of Hampton Roads on Virginia, Silberman found that for the existing port operations a multiplier effect of 2.27 was appropriate for the port area (Silberman, 1980). Thus, it may be concluded that the multiplier of 3.0 used by AOV Industries is about right, considering that new port facilities were being constructed. After the construction and start-up phase of a new coal terminal is over, however, it may be expected that employment levels will drop as normal operations begin. Therefore, the estimated 3.0 multiplier could drop toward the 2.27 value found by Silberman, or even lower values.

Silberman also found that the movement of 1,000 tons of coal create about one job. Hence, the movement of 40 million tons of coal (the figure used for planning purposes) would be expected to generate about 40,000 jobs from the mine to the port. If these figures are accurate, and if they are transferable to North Carolina coal movements, the following points may be made.

According to NCDNRCD estimates, about 400 additional port employees will be required to load 40 million tons of coal annually. Extrapolating from the 24 additional railroad employees Southern hired to move coal at the rate of three million tons annually, 320 additional railroad employees will be necessary to move 40 million tons annually (AOV, 1981). Assuming a multiplier of 3.0 applied to the 720 jobs, a total employment impact of 2,880 jobs results from the primary and secondary industries related to transporting and shipping the coal. According to Silberman's results, an additional 37,112 jobs are likely to be generated by industries attracted or induced to expand by the improved port facilities. It thus seems reasonable to assume that the primary industrial expansion will occur in the out-of-state mining industry, and it remains to be seen what industries will be compatible with and attracted to the coal-related rail and port operations. Basically, the issue is whether North Carolina will receive adequate economic benefits to "compensate" for the "inconvenience" of having coal trains and coal terminals operate within the state, or whether, as Silberman's figures suggest, much of the industrial expansion and resulting economic benefits will occur elsewhere. This issue becomes more

pronounced when the impacts of coal trains moving through communities are considered.

3.1.2 Inland Economic Benefits

The potential inland economic benefits from increased rail traffic to and from existing and planned port facilities in the Carteret County and the New Hanover-Brunswick County areas are discussed in this section. The rail traffic is assumed to move on the one north-south rail corridor (Rocky Mount, Wilson, Goldsboro, and Wilmington) and the two east-west rail corridors (Wilson, Greenville, Chocowinity, New Bern, and Morehead City; Goldsboro, Kinston, New Bern, and Morehead City) described previously (see Section 2.3). While the economic benefits will be analyzed in terms of increased railroad employment due to growth of rail traffic, two qualifications must be added.

First, depending on the specific commodity being moved by rail, inland economic impacts other than those related to increased rail traffic are possible. For example, increased rail traffic due to greater market demand for lumber products and chemical products might imply increased jobs for North Carolina residents (see Section 2.2). If the growth in rail traffic is due to increased demand for coal, a commodity not produced in North Carolina, there would be no jobs created in the state related to the mining of the resource. However, determining whether or not other jobs besides those related to rail transportation are created in North Carolina due to the specific commodity being shipped is beyond the purview of the present analysis.

Second, while all increases in rail traffic imply growth in the number of jobs at the port facilities themselves, the economic benefits of such employment is not considered as part of this particular analysis. Section 3.1.1 covers port employment impacts.

In analyzing the economic benefits from increased rail traffic it is recognized that there are several aspects of railroad employment which may well be affected, e.g., train operation and maintenance, track maintenance, and railroad management. The most readily apparent impact for the coastal study area will be in train operation, i.e., the crew which

actually operate the trains, and it is this employment which is of concern here. The analysis is based on a series of assumptions concerning: (1) the number of crews per train movement, (2) the number of crew members on each crew, and (3) the number of train movements per day.

As mentioned, there is one north-south rail corridor (SCL) which moves cargo to and from the Wilmington port area. There are two alternative west-east rail corridors (converging at New Bern) which move cargo to and from Morehead City's port facilities. Of importance in identifying the number of crews per train movement is the geographical places at which crews are changed in the coastal study area. For the north-south corridor, crews are exchanged at Rocky Mount. For the west-east rail line, crews on the Raleigh-Goldsboro-New Bern-Morehead City route are exchanged at Goldsboro and crews to the Raleigh-Wilson-Greenville-New Bern-Morehead City route are exchanged at New Bern. For all the rail routes the crews moving toward the ports are considered turnaround crews, i.e., they move the trains to and from the port areas. Thus for each train movement into the coastal study area there will be one crew, and for each train movement out of the coastal study area there will be one crew which takes the train from the exchange point out of the area. Thus, two crews are needed to move a train in and out of the study area.

According to railroad estimates each train crew is comprised of four members. Thus each movement will require four railway employees, and the movement of a train in and out of the study area will require eight employees.

For the purposes of the present analysis, the 40 million tons of increased rail traffic is estimated to total 24 train movements per day (12 entering and 12 leaving the study area). Using the preceeding assumptions, the 24 train movements would require 24 crews per day split evenly between the north-south and the west-east corridors. Assuming four-man crews, a total of 96 employees are required to move the trains on a given day. However, the number of employees on each route to move the 84 trains during a given week would be greater since the crew members would not work a seven day week, the actual number of employees would be approximately 144 assuming a 50% increase to cover weekends, vacations, and sick leave.

Assuming that the 144 new railroad employees are evenly split between the corridors and that they would reside in the county in which the crew exchange points are located, the impact would be minor. Using 1980 employment data, an increase of 72 employees for Craven County (New Bern) would increase the total employment by less than .5 percent. An increase of 72 employees for Wayne County (Goldsboro) would increase total jobs by less than .4 percent. An increase in employment by 72 persons for Nash County (Rocky Mount) would result in an increase of less than .4 percent. However, given the mobility of railroad employees it seems safe to assume that the actual growth in crew employment would be less. Besides the crews required to operate the trains, additional employees will be required to service the trains and maintain the tracks.

In conclusion, any growth in employment from increased rail traffic in the coastal study area would be limited to the communities in which crews are exchanged. Given the nonmetropolitan character of the affected communities, the multiplier effect of these new jobs would be at the lower range of values (1.5) so that a conservative estimate would be new employment would total approximately 200 to 300 persons. Although an important source of new employment, the overall impact would affect the local labor force by less than 1 percent.

3.2 Rail/Community Conflicts

If a total of 40 million tons of coal are exported from North Carolina annually (20 million from Morehead City and 20 million from Wilmington), as many as 30 unit train movements to and from the ports will occur daily (Stone, 1981). Typically, communities along the routes will encounter 12 to 15 of these movements since the routes are different for the two ports; but in Wilson or Goldsboro the routes will intersect, and one of these communities will encounter all of the movements. Needless to say, the coal trains necessary to move 40 million tons of coal annually through North Carolina will represent a substantial increase over existing rail traffic.

Coal trains will most likely have negative socioeconomic and environmental impacts on the communities through which they pass. How a community

responds to the impacts will depend on the impact type and magnitude and on the previous history of heavy train movements through the community. The citizens who have become accustomed to prior train traffic will tolerate more disruption than people who have not, especially if they perceive that higher rail traffic means economic growth and that it benefits them directly.

Negative impacts are of two general types: environmental impacts and impacts at grade crossings. Environmental impacts include noise, dust, and vibration - all of which appear to be of less concern to most townspeople than impacts at grade crossings. Dust may be controlled by moisture treatment of the coal when it is loaded at the mine, and noise and vibration may be reduced by changing train operation procedures and by installing welded rails in order to eliminate the bothersome "clickity-clack" of jointed tracks. Some grade crossing impacts, however, may not be remedied short of halting coal shipments or relocating the rail corridor.

Grade crossing impacts include potential delays to general highway traffic and emergency service vehicles, train-vehicle collisions, severence of community service and business patterns, and derailments. The severity of the impacts depends on the volume of the coal train traffic, the volume of the crossing highway traffic, the number of grade crossings, and their proximity to business and population concentrations. While several methodologies to estimate the impacts may be used, one developed and applied by the Minnesota and North Dakota departments of transportation has received particular professional recognition (MNDOT,1980). The methodology uses detailed data on the community, railroad operations, and highway traffic at grade crossings to estimate rail/community conflicts. This comprehensive methodology is used in this study.

3.2.1. Traffic Delay at Grade Crossings

Traffic delay consists not only of the time that a crossing is actually blocked by a train, but also the time it takes the traffic queue to dissipate and the traffic flow to return to normal. For typical streets the total delay may be twice the actual blocked crossing time of 5 to 10 minutes; for worst case situations (24th Street in Morehead City) the total delay may exceed one hour.

In order to calculate traffic delay, grade crossings may be simply treated as "isolated" traffic locations (Appendix A), or, in a more complex approach, as part of a network. If a network approach is used, the effects of a blocked crossing on adjacent streets and traffic flow may be determined if desired. In this study, however, many of the crossings are indeed "isolated" in small communities or rural locations and the simplified approach is justified. Furthermore, the simplified approach was tested against the results of a network approach for the medium size city of Wilmington and the results were very comparable (Anderson and Assoc., 1982). Hence, the simplified approach also appears justified for the larger case study communities of Rocky Mount, Wilson, Goldsboro, etc.

Traffic delay depends on the number of daily trains, the time of day they operate, their length and speed, the volume of automobile traffic that uses the crossing, and street capacity characteristics (number of lanes, parking conditions, etc.). Information of this type for each analyzed crossing was obtained from existing railroad and traffic data bases on file at the North Carolina Department of Transportation and in some cases from the communities and railroad companies concerned.

As discussed in detail in Appendix A, train, street, and traffic data for particular crossings are used to calculate the duration of vehicle queues that form at blocked crossings, the number of affected vehicles per blockages, and the total vehicular delay per blockage. For each crossing, the traffic disruption is calculated assuming it occurs during rush hour and during non-rush hour. Then the train operation hours are considered so that the existing total traffic disruption on a daily basis can be delayed.

Similar calculations are made to approximate future traffic delay assuming increased train operations but no increased automobile traffic. Assuming local traffic will not increase is a conservative assumption since most communities are expected to grow in the future and, hence, have greater traffic volumes. Since queue duration increases with the square of approach volume, a 10% growth in future traffic would suggest that the future values of queue duration documented in this report should be multiplied by a factor of 1.21. Similarly if traffic were to increase 20%,

tabular values for future queue duration should be multiplied by a factor of 1.44. Such modifications were not incorporated directly in the analysis because of the wide variability of traffic volume predictions depending on the street location and community development patterns. Local planners, however, can easily modify the results of this report as discussed above to reflect changes in future traffic for their communities.

Table 3-1 shows comparisons of existing traffic disruptions in the case study communities to future disruptions resulting from major increases in rail movements to and from the state ports. Table 3-2 presents similar information for selected rural crossings. As discussed in Appendix A, the crossings picked for analysis for urban and rural locations had an average daily traffic volume of at least 2000. Using this selection criterion, 83 community port corridor crossings and 32 major rural crossings were investigated.

Perhaps the major factor for comparing traffic delays at grade crossings is total delay (columns 6 and 11, Table 3-1). As can be seen in Table 3-1, the total vehicle delay for communities ranges from almost nothing to over 50,000 vehicle-minutes per day. To help place the values in Tables 3-1 and 3-2 in perspective, approximately 500 to 1000 vehicle-minutes delay per day can occur at typical traffic signals. Hence, the present train related delay in Rocky Mount, for example, is about 4000 daily vehicle-minutes, or equivalently, the effect of four to eight traffic signals. If train traffic were to increase by 12 daily trains, total vehicle delay would increase to about 7000 daily vehicle-minutes. The additional 3000 vehicle-minutes of delay could thus be roughly compared to the delay effects caused by installing three to six new traffic signals in town. Similar analogies of traffic signals to train movements can be made for the other communities. For example, the delay impacts of future train movements in Wilson would be analogous to installing 20 to 40 new traffic signals; in Morehead City, 50 to 100 signals.

3.2.2. Emergency Vehicle Delays and Route Deviations

Medical, fire, and police emergency responses can be delayed at grade crossings by passing trains. Not only can the responding vehicles

TABLE 3-1 Summary Comparisons for Daily Traffic Disruptions for Selected Crossings in Case Study Communities

Community	Present					Future				
	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Rocky Mount	3	13	210	3202	4015	5	23	367	5542	6,949
Wilson										
SOU	1	3	266	1899	6981	3	13	1040	6881	25,299
SCL	3	15	324	1734	2184	5	25	539	2890	3,640
Goldsboro										
SOU	-	2	108	514	1028	2	12	771	4350	8,684
SCL	-	2	27	92	182	2	12	190	770	1,528
Warsaw	-	3	17	57	75	2	13	88	360	474
Wilmington	-	2	166	1212	2752	2	12	1222	10508	23,850
Boiling Spring Lakes	-	2	17	4	8	2	12	284	102	362
Greenville										
SOU	1	3	315	2093	5906	3	13	1251	7855	22,154
SCL	1	3	397	2841	8014	-	-	-	-	-
New Bern	1	3	182	1361	3859	3	13	723	5055	14,341
Kinston										
SOU	-	2	113	606	1716	2	12	808	5048	14,290
SCL	1	3	78	517	1465	-	-	-	-	-
Morehead City	-	2	120	1066	5644	2	12	963	10552	55,842

TABLE 3-2 Summary Comparison for Traffic Disruptions for Selected Rural Crossings

Crossing Location	Present					Future				
	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Brunswick Co.										
NC 133 (310 655V)	-	2	3.6	10	8	2	12	25.6	84	68
Carteret Co.										
SR 1247 Chatham St. (SOU 722 664H)	-	2	6.0	24	30	2	12	42.8	198	250
US 70 (SOU 722 672A)	-	2	6.0	20	26	2	12	43.0	166	216
SR 1177 (SOU 722 649F)	-	2	5.6	14	18	2	12	39.8	114	146
Craven Co.										
NC 55 (SOU 722 711N)	-	2	12.4	112	316	2	12	88.2	920	2600
SR 1402 (SOU 722 710G)	-	2	13.6	78	222	2	12	98.8	666	1894
SR 1215 (SOU 722 709M)	-	2	13.0	58	166	2	12	93.6	488	1390
US 17 Bypass (NS 466 092D)	-	2	5.6	14	18	2	12	39.6	112	146
SR 1616 (NS 466 051Y)	-	2	5.6	10	14	2	12	39.6	84	114
US 17 (NS 466 041T)	-	2	6.6	46	60	2	12	48.6	398	520
SR 1745 & SR 1756 (SOU 722 674N)	1	3	27.8	173	487	3	13	109.8	647	1821
Duplin Co.										
NC 403/50 (SCL 628 815P)	-	3	8.4	21	30	2	13	42.6	123	172
SR 1173 (SCL 628 652H)	-	3	8.7	27	36	2	13	44.1	157	208
NC 41 (W. Main St.) (SCL 628 653P)	-	3	8.4	42	54	2	13	42.2	240	310
Halifax Co.										
SR 1641 (SCL 629 654A)	3	13	47.9	262	338	5	23	83.7	454	586
NC 125/903 (SCL 629 659J)	3	13	44.1	158	196	5	23	79.9	274	345

TABLE 3-2 cont.

Crossing Location	Present					Future				
	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Halifax Co. (cont.)										
NC 481 (SCL 629 670J)	3	13	45.7	158	199	5	23	79.9	274	345
Lenoir Co.										
SR 1546 (SOU 722 825B)	-	2	5.6	10	14	2	12	39.4	82	112
US 258 (SOU 722 822F)	-	2	6.2	32	42	2	12	44.8	270	356
Nash Co.										
NC 231 (NS 465 640K)	1	5	17.6	57	73	3	15	52.8	171	219
NC 44 (SCL 629 679V)	3	13	44.1	139	177	5	23	77.1	241	307
New Hanover Co.										
SR 1318 (SCL 628 712P)	-	3	8.4	18	24	2	13	42.4	106	140
SR 1322 (SCL 628 716S)	-	3	9.3	51	66	2	13	48.1	307	398
SR 1302 (SCL 628 721N)	-	3	9.9	66	87	2	13	51.7	406	533
Northampton Co.										
NC 46 (SCL 629 643M)	3	13	46.3	218	278	5	23	80.9	378	482
Pender Co										
NC 53 (SCL 628 683G)	-	3	9.0	33	45	2	13	45.8	195	263
NC 210 (SCL 628 695B)	-	3	8.4	15	18	2	13	42.2	85	104
Pitt Co.										
US 264 (NS 465 544H)	1	3	11.3	72	96	3	13	45.1	272	364

TABLE 3-2 cont.

Crossing Location	Present					Future				
	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Peak Hour Trains	Off Peak Trains	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Pitt Co. (cont.)										
US 258 (NS 465 540F)	1	3	12.4	59	80	3	13	49.2	221	300
US 264A (NS 465 535J)	1	3	11.4	32	42	3	13	45.4	120	158
Wayne Co.										
US 13 (SOU 722 861W)	-	2	9.2	40	80	2	12	66.0	336	670
Wilson Co.										
NC 58 (NS 465 577V)	1	3	11.9	36	46	3	13	47.3	128	162

be delayed, but also the volunteers can be delayed on their trip to the station to pick up the vehicle. In studies similar to this one (Minnesota DOT, 1980) residents in rail corridors identified emergency service delays as the most serious community problem resulting from rail operations. This was especially true for communities where one emergency medical, fire, and police organization served areas on both sides of the main line. For the North Carolina case study communities, however, multiple emergency services (especially fire stations) are located in all sections of the larger communities and residents were not as concerned about the delays, according to community comments collected during this study.

To estimate the potential number of emergency response delays, the number of times the mainline must be crossed during a period of time is multiplied by the probability that the track will be blocked during that time. Appendix B describes the details of this calculation for the composite number of delays and route deviations on a community wide basis. Table 3-3 presents the results of the medical delay calculations, and Table 3-4 gives fire emergency delays.

The number of potential emergency medical delays or route deviations currently occurring in the case study communities ranges from a low of 0 in Boiling Spring Lakes to as many as 500 per year in Wilson where the city is cut into quadrants by the railroads. The average number of potential delays or route deviations for the case study communities, excluding Wilson, is 10 per year. This number includes potential delays at crossings plus route deviations which also result in delayed arrivals at emergency scenes or at the hospital with emergency patients. In the future if 12 additional train movements occur in the case study communities (24 in Wilson and Goldsboro), the potential delays could quadruple to 40 per year on the average. Similar comments can be said about the potential delays that could be experienced by fire vehicles except that their rate of occurance is about one-sixth that of medical delays.

The ultimate concern with emergency service delays is the consequence of such delays. For fire and police emergencies, it is obvious that additional property loss or inability to apprehend a criminal may result. But to estimate how many times this might occur as a result of the delays

TABLE 3-3 Potential Emergency Medical Service Delays or Route Deviations

Community	Affected Ambulance Services or Rescue Squads	Average Annual Calls	Potential Annual Delays or Route Deviations					
			Ambulance		Volunteers		Total	
			Current[1]	Future[2]	Current	Future	Current	Future
Rocky Mount	Stony Creek R.S.	4550	63	110	0	0	63	110
Wilson	Wilson Co. R.S. Wilson Co Hospital Amb.	6059	516	1548	-[4]	-	516	1548
Goldsboro	Goldsboro R.S.	1661	18	72	0	0	18	72
Warsaw	Warsaw R.S.	300	1	5	1	6	2	11
Wilmington[5]	Headquarters	2814	4	29	-	-	4	29
	Empie	1252	2	18	-	-	2	18
Boiling Spring Lakes	B.S.L. R.S.	78	0	3	0	0	0	3
Greenville	Memorial Drive R.S.	1431[3]	22	88	-	-	22	88
New Bern	Craven Co. Hospital Amb.	1996	9	36	0	0	9	36
	Pamlico Co. R.S.	280	4	17	0	0	4	17
Kinston	Lenoir Co.	2819	3	21	-	-	3	21
Morehead City	Morehead R.S.	600	11	77	8	56	19	133
	Atlantic Beach R.S.	225	3	21	0	0	3	21
	Pine Knoll Shores R.S.	100	1	9	0	0	1	9
	Bogue Banks R.S.	50	1	4	0	0	1	4

[1]See Table 3-1 for current rail movements.

[2]See Table 3-1 for future rail movements.

[3]Approximation based on 1 medical emergency response per day per 5000 population.

[4]Data unavailable.

[5]Results based on data from Anderson and Assoc., 1982.

TABLE 3-4 Rail Conflicts with Fire Station Responses

Community	Affected Fire Stations	Average Annual Calls	Potential Annual Delays and Route Deviations[2]					
			Firetruck		Volunteers		Total	
			Current	Future[7]	Current	Future	Current	Future[7]
Rocky Mount[1]	Secondary	1000	1-3	2-5	-[6]	-	1-3	2-5
Wilson[1]	Secondary	847	1-2	3-6	-	-	1-2	3-6
Goldsboro[1]	Secondary	624	1-2	4-8	-	-	1-2	4-8
Warsaw	Primary	100	Neg.[3]	Neg.	Neg.	Neg.	Neg.	Neg.
Wilmington[1,5]	Primary							
	Headquarters	1497	2	14	0	0	2	14
	Empie	490	0-1	3	0	0	0-1	3
	Secondary							
	Willard	1175	1	7	0	0	1	7
	Princess Place	493	0-1	3	0	0	0-1	3
Boiling Spring Lakes	Primary	28	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Greenville[1]	Secondary	239[4]	0-1	0-4	-	-	0-1	0-4
New Bern[1]	Secondary	476	1-2	4-8	-	-	1-2	4-8
Kinston[1]	Secondary	337	1-2	7-14	-	-	1-2	7-14
Morehead City[1]	Secondary	264	0-1	0-7	-	-	0-1	0-7

[1] In the larger communities sections bounded by tracks have at least one primary responder in that section so there is little or no delay. Secondary responders may be delayed.

[2] Detailed data is unavailable, however, approximately 1 to 3 delays or route diversions per 1000 responses may be expected based on reported community data and the results of other studies.

[3] Negligible numbers of delays or route deviations.

[4] Estimated by one fire call per day per 30,000 population.

[5] Estimates based on the results of Anderson and Assoc., 1982.

[6] Data unavailable.

[7] Future estimates proportional to percentage increase in rail movements.

at crossings or extra response time due to route deviations is difficult if not impossible.

For emergency medical responses, however, it is possible to estimate the relative percentage of patients who are sensitive to a delay in treatment. One study found that approximately 5 to 10 percent of medical emergencies are life-threatening prior to the provision of on-site treatment, and that one to two percent remain life-threatening until emergency room treatment is begun (Andrews, 1978). Such cases demand on-site attention within 15 minutes and hospital treatment within 70 minutes. The actual consequences of any delay depend on the patient's condition, the elapsed time prior to treatment, and the patient's location relative to emergency room service. Ignoring the issue of increased patient suffering resulting from delay, a five-minute delay in treatment, for example, would affect the chances of survival of "only" one or two percent of the patients if they are located less than ten minutes from the ambulance station. On the other hand, if an emergency patient is located nearly 15 minutes from the ambulance station, a delay of one minute may mean the difference between life and death (Minnesota DOT, 1980). As a result of the time and location complexities associated with medical responses, the actual number of life-threatening delays is hard to calculate. It may be concluded, however, that delays in treatment that critically affect the chances of patient survival are relatively few in number. Such life-threatening delays may be as low as one percent or perhaps as high as 10 percent of the potential annual delays or route deviations. For the case study communities the current level of delays could, thus, critically affect about 10 to 100 of the more than 24,000 annual medical emergency responses. With an additional 12 train movements in the rail/port corridors, perhaps as many as 20 to 200 critical delays would occur in the future.

3.2.3. Grade Crossing Accidents

Many communities are concerned with safety at grade crossings. They recognize the danger to school buses and pedestrians, as well as that to general vehicular traffic. Unfortunately no validated methods for estimating school bus and pedestrian accidents were found for this study. An excellent method was found, however, for estimating total

vehicle accidents. The method is based on recent research conducted by the U.S. Department of Transportation, and its details are presented in Appendix C. The results of applying the method are shown in Table 3-5.

As a point of reference the average accident rate for grade crossings in North Carolina is one to two accidents over a twenty year period. This means that for one year the average accident rate is 0.05 to 0.10. Alternatively, there is a 5% to 10% chance of an accident occurring at a typical crossing in 20 years, or 0.25% to 0.50% chance in one year. Whether or not an accident does occur depends on many technical and human factors. Some of the technical factors include vehicle and train traffic, type of crossing protection, train speed, number of tracks, and distance from the crossing that vehicles can sight an approaching train (Mallard, 1981, 1982). Human factors have not been thoroughly investigated, but it is expected that age, sobriety, and past traffic violation history may play a role.

Comparing the average yearly rate of 0.05 to 0.10 accidents per crossing to the results displayed in Table 3-5, it is seen that nearly all of the communities studied could expect significant changes in rail related accidents, and that the future accident rates will in general exceed the current statewide average.

3.2.4. Vehicle Fuel, Pollution, and Delay Costs at Crossings

Traffic delays caused by blocked crossings result in not only time losses but fuel losses as well, through vehicle idling and queue starting delays. Table 3-6 lists the amount of gasoline consumed daily in each community, due to vehicular delays resulting from rail movements. These figures were based on an average fuel consumption rate, at idle, of 0.01 gallons/minute/vehicle, multiplied by the total delay per day, in vehicle minutes, experienced by a particular community (Appendix D).

A second impact of vehicle delay is increased emissions of carbon monoxide (CO) and various hydrocarbons (HC). The quantity of pollutants emitted was determined in a manner similar to that used for estimating fuel consumption, with the average level of emissions per vehicle being

TABLE 3-5 Grade Crossing Accidents

Location	Crossings Analyzed	Composite[1] Yearly Accident Rate for the Crossings Analyzed		Average Yearly Accident Rate per Crossing	
		Current	Future	Current	Future
Rocky Mount	SCL 4	.20	.32	.05	.08
Wilson	SCL 6	.13	.20	.02	.03
	NS 6	.87	1.47	.12	.21
Goldsboro	SCL 3	.25	.72	.08	.24
	SOU 12	.93	2.09	.08	.17
Warsaw	SCL 2	.12	.26	.06	.13
Wilmington	SCL 15	1.37	3.80	.09	.25
Boiling Spring Lakes	USA 3	.04	.14	.01	.05
Greenville	NS 12	1.03	1.89	.09	.20
New Bern	SOU 7	.90	1.28	.13	.18
Kinston	SOU 9	.72	1.79	.08	.20
Morehead City	SOU 4	1.02	2.05	.26	.51
Brunswick Co.	310 655V	-	-	.03	.06
Carteret Co.	SOU 722 672A	-	-	.15	.44
Lenoir Co.	SOU 722 825B	-	-	.05	.16
Northampton Co.	SCL 629 693M	-	-	.08	.11
Pender Co.	SCL 628 695B	-	-	.06	.12

[1]Composite means the sum of the accident rates for the community crossings studied.

TABLE 3-6 Daily Vehicle Fuel, Pollution and Delay Costs at Crossings

Community	Present					Future				
	Total Delay (veh-min)	Avg. Daily Fuel Consump. (gallons)	Avg. Pollutant Emissions (kgCo)	(kgHC)	Avg. Daily Time Delay Cost ($)	Total Delay (veh-min)	Avg. Daily Fuel Consump. (gallons)	Avg. Pollutant Emissions (kgCO)	(kgHC)	Avg. Daily Time Delay Cost ($)
Rocky Mount	4015	42	103	15	384	6949	72	179	26	665
Wilson										
SOU	7002	73	180	26	730	25390	264	653	95	2648
SCL	2184	23	56	8	228	3640	38	94	14	380
Goldsboro										
SOU	1028	11	26	4	98	8684	90	223	33	831
SCL	182	2	5	1	17	1528	16	39	6	146
Warsaw	75	1	2	0	6	441	5	11	2	38
Wilmington	2752	29	71	10	297	23850	248	614	89	2572
Boiling Spring Lakes	2	0	0	0	0	732	8	19	3	86
Greenville	5906	61	152	22	594	22154	230	570	83	2227
New Bern	2468	26	64	9	284	9248	96	238	35	1064
Kinston	1716	18	44	6	176	14290	149	368	54	1468
Morehead City	5644	59	145	21	478	55842	581	1437	209	4732
TOTALS	32974	345	848	122	3292	172748	1797	4445	649	16857

[1] Assumes an average per vehicle gasoline consumption rate of 0.01 gal/min at idle. Source: NC Energy Division, 16 Steps to Conserve Energy on NC Highways.

[2] Assumes no change in the wage rate.

determined from data presented in a recent study of four grade crossings in an urban area in northwest Indiana (Powell, 1982). Again, total delay per day in vehicle-minutes was used as the multiplier to obtain the final result. These results are also presented in Table 3-6. Appendix D provides an example calculation.

Perhaps a more difficult impact to quantify is the "cost" associated with the amount of time an individual is delayed by a rail movement. A dollar figure has been derived for each community, based on the total delay resulting from rail movements in that community. To obtain this figure, the assumption was made that the value of time to an individual is equivalent to his or her employment value. The data used in this case was average wage data for the counties involved, compiled by the North Carolina Employment Security Commission (NCESC, 1978). An extrapolation was used to generate expected wage rates for the current year, based on historical increases. In addition, the assuption was made that each vehicle delayed carries one employed individual. The weekly wage rates used for each community to determine the time delay cost, in dollars, are presented in Appendix D. The results of the delay cost calculations are shown in Table 3-6.

3.3 Critical Impact Areas

To briefly review the report to this point, three major rail corridors to Morehead City and Wilmington were selected for study. Along those corridors, 10 communities and a number of rural locations were chosen for impact assessment. Within the communities grade crossings with more than 2000 vehicle crossings per day were identified and their impacts estimated for current mainline operations. Assuming that rail operations will increase by an additional 12 daily through trains in each corridor as a result of increased port activity associated with coal exports or other commerce, the future grade crossing impacts were estimated. Community-wide values were calculated for general traffic delay, emergency vehicle delay, accidents, fuel, and pollution.

It is the purpose of this section to examine the impacts and identify critical problem locations on a community basis. The impact estimates

presented in the preceeding Tables 3-1 to 3-6 suggest a wide range of problem magnitudes for the selected areas and grade crossings. Controlling for percentage increase in impact and for population size, however, reveals less diverse relative problem magnitudes among the communities. It also reveals that small communities on a percentage or a per capita basis can experience greater problems than larger communities. Similar results have been found in other studies (Minnesota DOT, 1980). When examining the percentage and per capita impacts of Tables 3-7 and 3-8, however, a few points should be considered.

First, how a community reacts to rail traffic impacts will depend on the impact type. One community may be more sensitive to potential grade crossing accidents; another may be more concerned with emergency vehicle delay. In this analysis, however, no attempt is made to weight the importance of the impacts; that will be left up to the communities themselves.

Second, the magnitudes and community experience with the railroad impacts affect how communities perceive their problems. Residents who have become accustomed to prior train traffic will tolerate more disruption than those who have not, especially if they perceive that the traffic benefits them. In an attempt to address problem perceptions with respect to relative magnitude and past experience, percentage increases and per capita values for the impacts are calculated. The per capita calculations normalize the impacts by the size of the community and allow relative comparisons between communities to be made. The per capita values can be interpreted as how each community resident, on the average, will share the impacts.

For example, Table 3-8 shows that each Rocky Mount resident can expect to wait an additional 60 minutes per year at the four crossings analyzed, use an additional 0.62 gallon of fuel, and contribute some small amount of pollutants. That same resident has an expected increase in probability of 0.26% of having personal emergency medical services delayed by a train, a 0.01% probability increase of having a fire response delayed, and a 0.0008% probabillity increase of being in a train related accident during a year's time. Similar interpretations can be made for the other

TABLE 3-7 Percentage Increase in Impacts Assuming Twelve Additional Train Movements

Community	No. of Crossings Consid.	Rail Operations		% Increase							
								Other Impacts			
				Traffic Delays	Medical Emergency Delays[1]	Fire Emergency Delays[1]	Grade Crossing Accidents	Fuel Consumption	Emissions		Delay Cost
		P	F						CO	HC	
Rocky Mount	4	16	28	73	75	100	50	71	75	73	73
Wilson		22	46	215	200	200	70	215	217	221	216
(SCL)	6	(4)	(16)				(100)				
(SOU)	6	(18)	(30)				(67)				
Goldsboro		4	28	744	300	300	133	715	745	680	750
(SCL)	12	(2)	(14)				(250)				
(SOU)	3	(2)	(14)				(133)				
Warsaw	2	3	15	532	450	negligible	200	436	491	-[2]	581
Wilmington	15	2	14	767	467	575	171	755	765	790	766
Boiling Spring Lakes	3	2	14	4425	-[2]	negligible	150	-	-	-	-
Greenville (SOU)	12	4	16	275	300	300	90	277	275	277	275
New Bern	7	4	16	272	308	300	44	269	272	289	275
Kinston (SOU)	9	2	14	733	600	600	157	728	736	800	734
Morehead City	4	2	14	889	596	600	100	885	891	895	890

[1] Includes route deviations.

[2] Since present impacts are zero or negligible, the % increase is infinite.

TABLE 3-8 Per Capita Impacts Resulting From 12 Additional Train Movements

Community	Population	Annual Per Capita Impacts (Future)							
		Traffic Delays (veh-min)	Medical Emergency Delays	Fire Emergency Delays	Grade Crossing Accidents	Other Impacts			
						Fuel Consumption (gal)	Emissions		Delay Cost ($)
							kg CO	kg HC	
Rocky Mount	42,418	60	.0026	.0001	.000008	0.62	1.54	0.22	5.72
Wilson	34,328	307	.0450	.0001	.00004	3.20	7.92	1.16	32.10
Goldsboro	33,899	110	.0021	.0002	.00008	1.14	2.82	0.42	10.52
Warsaw	2,950	59	.0037	-	.00009	0.67	1.46	0.26	5.04
Wilmington	44,000	198	.0013	.0006	.00009	2.06	5.09	0.74	21.34
Boiling Spring Lakes	998	132	.0010	-	.00014	1.44	3.42	0.54	15.49
Greenville (SOU)	35,740	230	.0025	.0001	.00005	2.35	5.82	0.85	22.74
New Bern	14,557	359	.0036	.0008	.00009	3.72	9.25	1.36	41.35
Kinston (SOU)	25,234	207	.0008	.0004	.00007	2.16	5.32	0.78	21.23
Morehead City	15,803*	1290	.0106	.0002	.00013	13.42	33.19	4.83	109.29

*Population is for Morehead township; this is considered to be the population whose travel would generally be affected by the rail corridor in question.

communities, however, the per capita calculation tends to deemphasize the impact on residents who live near and cross the rail corridor, and it tends to exaggerate the impact for residents who live away from the corridor.

The third point to consider when examining the impact tables, especially the summary Table 3-9 which ranks communities by impact, is that many crossings with less than 2,000 daily vehicles crossings were not considered. In Rocky Mount, for example, six such minor crossings were not considered. Including the minor crossings would increase the community wide impacts and, depending on their number may change the order of the ranking in Table 3-9.

Assuming the order of Table 3-9 is appropriate and not applying any relative weighting to the impact categories, composite impact scores may be assigned to the cities. Assigning 10 to the highest ranked city in each category of Table 3-9, 9 to the second ranked city, and so forth, and then summing each city's scores, the cities may be ranked by the composite impacts due to traffic delays, medical emergency delays, fire emergency delays,and grade crossing accidents. The results in decreasing order of impacted community are as follows:

1. Morehead City and New Bern (tie)
2. Wilmington and Wilson (tie)
3. Greenville
4. Goldsboro and Kinston (tie)
5. Boiling Spring Lakes
6. Warsaw
7. Rocky Mount

Note: Twenty-six additional small towns and villages could be added to this list. Hence, relative rankings could change.

It is seen that three of the top four cities have already been identified as being impacted by major rail traffic increases. Detailed local studies for these cities (Morehead City, New Bern, and Wilmington) will be completed in August 1982. The above list suggests that attention should now be shifted to Wilson, Greenville, Goldsboro, and the others.

It should be noted that if weights were applied to the impact categories, somewhat different rankings might occur. Such a weighting process might address community values, economic costs, and probabilities associated with the impacts, and the like. Community representatives working

TABLE 3-9 Ranking of Communities by Per Capita Impact

% Increase in Rail	Traffic Delays	Medical Emergency	Fire Emergency	Grade Crossing	Fuel Consumption	Emissions		Delay Cost
						CO	HC	
Boiling Spring Lakes[1]	Morehead City	Wilson	New Bern	Boiling Spring Lakes	Morehead City	Morehead City	Morehead City	Morehead City
Goldsboro[1]	New Bern	Morehead City	Wilmington	Morehead City	New Bern	New Bern	New Bern	New Bern
Kinston[1]	Wilson	Warsaw	Kinston	New Bern[2]	Wilson	Wilson	Wilson	Wilson
Morehead City[1]	Greenville	New Bern	Goldsboro[3]	Warsaw[2]	Greenville	Greenville	Greenville	Greenville
Wilmington[1]	Kinston	Rocky Mount	Morehead City	Wilmington[2]	Kinston	Kinston	Kinston	Kinston
Warsaw	Wilmington	Greenville	Greenville[4]	Goldsboro	Wilmington	Wilmington	Wilmingotn	Wilmington
Greenville[2]	Boiling Spring Lakes	Goldsboro	Rocky Mount[4]	Kinston	Boiling Spring Lakes	Boiling Spring Lakes	Boiling Spring Lakes	Boiling Spring Lakes
New Bern[2]	Goldsboro	Wilmington	Wilson	Greenville	Goldsboro	Goldsboro	Goldsboro	Goldsboro
Wilson	Rocky Mount	Boiling Spring Lakes	Boiling Spring Lakes[5]	Wilson	Rocky Mount[5]	Rocky Mount	Warsaw	Rocky Mount
Rocky Mount	Warsaw	Kinston	Warsaw[5]	Rocky Mount	Warsaw[5]	Warsaw	Rocky Mount	Warsaw

[1]Shares first-place ranking and is listed alphabetically.
[2]Shares 3rd-place ranking and is listed alphabetically.
[3]Shares 4th-place ranking and is listed alphabetically.
[4]Shares 5th-place ranking and is listed alphabetically.
[5]Shares last-place ranking and is listed alphabetically.

with state policy makers and planners could attempt such a weighting process in order to establish an official priority list of communities requiring rail improvements - a list that would replace the example list above.

4.0 SOLUTIONS TO RAIL/COMMUNITY CONFLICTS

In order for rail/port commerce to increase by 20 million annual tons (approximately 12 additional train movements) in each rail/port corridor, the resulting increase in traffic related impacts on the communities will have to be overcome. Depending on the situation, high cost solutions such as grade separations and rail bypasses will be necessary. Or, low cost solutions such as changes in grade crossing protection, emergency service/railroad communication systems, and signal system and local ordinance changes to permit faster train speeds, may resolve the rail/community conflicts. Furthermore, innovative uses of alternative transportation modes such as pipelines and barges may be feasible.

The purpose of this section of the report is to briefly describe the types of solutions available. Typical implementation requirements and costs will be included.

4.1 High Cost Solutions

High cost solutions such as grade separations and rail bypasses are considered necessary when intolerable community disruption occurs. The disruption may affect all types of vehicular traffic as well as the community business activity as in the case of Morehead City. Or the disruption may severely upset neighborhood or historical sections, as well as business areas, as is the case in New Bern. High cost rail bypasses have been studied for these two communities (NCDOT, 1981; 1982) and will be briefly discussed as examples for what could be done elsewhere along the port-rail corridor should the need arise.

NCDOT has proposed three rail bypass alternatives for New Bern (NCDOT, 1981). Portions of each alternative route would require new right-of-way to be acquired, new track to be laid, and extensive overpasses to be built over rivers and marshland. The estimated capital

cost for the alternative preferred by NCDOT, is $55 million, and the bypass would require five to seven years to build. In addition to the capital cost, the project would have a possible negative impact on socio-economic, cultural, and environmental features of the New Bern area. Similar comments can be made about the four rail bypass alternatives for Morehead City except the costs range from $28 million to $64 million (NCDOT, 1982).

The costs for the New Bern and Morehead City bypass projects are typical of such alternatives. The average cost of the seven bypass projects is $45 million which compares to a national average of $55 million. Grade separation projects are much less expensive but still average several million dollars per location.

As can be seen, the costs of grade separations and rail bypasses are very high for just one or two communities. The cost of applying these solutions on a corridor basis would be enormous. Hence, if at all possible low cost solutions should be implemented. Typical examples will be briefly discussed in the following section.

4.2 Low Cost Solutions

If low-cost alternatives appear adequate to resolve rail/community conflicts, they will not only cost less, but also will be more rapidly implemented. According to a 1981 Minnesota DOT study, low cost solutions average about $160,000 per project and range in cost from several hundred dollars for improved public education to several hundred thousand dollars for improved grade crossing protection devices. Table 4-1 lists a number of low cost solutions to rail/community conflicts, categorizes them, and identifies the type of problem they are designed to mitigate.

4.3 Alternative Transportation Modes

While the focus of this report is on railroad and community related solutions, some mention must be made of switching to alternative transportation modes. For example, if the conflicts occur at a port or

TABLE 4-1 Potential Low-Cost Solutions to Rail/Community Conflicts

ACTION	PROBLEMS THE ACTIONS ARE DESIGNED TO ADDRESS IN THE CASE STUDY COMMUNITIES					
	EV	CD	AWS	ABS	VS	PS
RAILROAD OPERATING CHANGES						
Ensure standing trains do not unnecessarily activate the gates and flashers by stopping the trains short of the activation circuit, thereby eliminating unnecessary delays at crossings.		X	X	X	X	
Increase maximum allowable train speed through communities to reduce the amount of time crossings are blocked and vehicles delayed.	X	X	X	X		
Ensure that trains using sidings stop well clear of the crossings to avoid unnecessary crossing blockage and to avoid creating a visual obstruction of other approaching trains on parallel tracks.	X		X	X	X	
Schedule local switching operations to off-peak hours to reduce the number of motorists who will experience crossing delays		X	X	X		
Allow delayed vehicles to clear the crossing periodically while switching operations are being conducted.			X	X		
Break trains that must straddle crossings for several minutes to avoid excessive vehicle delays.	X		X	X		
Redistribute trains from one mainline to another; the mainlines are parallel but separated by a few hundred feet; the mainline to which trains would be distributed affects fewer people than the other.		X	X	X		
Relocate crew change points outside of or farther from the community to reduce the crossing delays associated with stopping the train.	X	X	X	X		
Reroute trains around communities using existing tracks.	X	X	X	X		
Relocate the train verifier farther from the community to eliminate slow train speeds in the community as the by-check operation is conducted.	X	X	X	X		
RAILROAD FACILITY CHANGES						
Install grade crossing predictors to activate the gates at crossings in order to reduce early signal activation, thus reduce delays and hazards at crossings.	X	X	X	X	X	X
Extend crossing gate arms to prevent motorists from crossing the mainline when the gates are down.					X	
Install automatic gates at crossings in place of less effective grade crossing protection devices.					X	
Alter rail sidings to eliminate blockage of crossings while trains use the sidings and to permit faster train speeds through the community while entering/exiting sidings.	X		X	X	X	
Construct fencing along rail right-of-way to inhibit pedestrians from crossing at unprotected locations.						X
Straighten track alignment to permit faster train speed through the community.	X	X	X	X		
Improve maintenance of the grade crossing surface.					X	
COMMUNITY FACILITY CHANGES						
Implement street and highway improvements designed to reduce delays at crossings and nearby intersections congested by vehicles delayed at crossings.			X	X	X	
Remove visual obstructions along the rail right-of-way near crossings.					X	
Close selected hazardous highway/rail grade crossings.					X	
Construct new crossings at both ends of the community as alternative routes for emergency vehicles only.	X					
Construct a grade separated pedestrian crossing.						X

TABLE 4-1 (cont.)

ACTION	PROBLEMS THE ACTIONS ARE DESIGNED TO ADDRESS IN THE CASE STUDY COMMUNITIES EV	CD	AWS	ABS	VS	PS
COMMUNITY SERVICE CHANGES						
More strictly enforce laws against crossing the tracks, violating activated warning signals.					X	
Upgrade ambulance service from a basic life support to an advanced life support system; this increases the ability to stabilize patients at the emergency scene and thus reduces the probability that a delay in traveling to the hospital will be critical.	X					
Equip fire service volunteers with personal equipment to conduct emergency operations prior to engine company arrival, thus reducing the adverse effects of crossing delay to the engine company.	X					
Establish emergency services on both sides of the mainline.	X					
Provide ambulance and fire service vehicles on both sides of the mainline.	X					
Relocate the emergency stations to the side of the mainline on which the majority of emergency calls occur, thus minimizing potential delays.	X					
Reroute school buses to avoid more hazardous crossings.					X	
Use alternative routes to respond to emergencies when first choice crossings are blocked by slow moving or standing trains.	X					
Establish a volunteer rescue squad to complement the existing ambulance service and to provide emergency medical service stations on both sides of the mainline.	X					
Establish a volunteer ambulance service to complement the existing private service and to provide emergency medical service stations on both sides of the mainline.	X					
Redesign transit bus routes to minimize times the mainline must be crossed.		X	X			
PUBLIC EDUCATION						
Institute pedestrian safety patrols for the safety of children crossing the mainlines on their way.						X
Conduct a marketing campaign to overcome people's perceptions of significant access problems to business centers.		X				
Conduct a pedestrian safety education program in the schools.						X
COMMUNICATIONS						
Establish an emergency service/railroad communication system to provide the capability to alter train operations and avoid blocking designated crossings in emergency situations.	X					
Improve general community/railroad communications.	X	X	X	X	X	X
COMMUNITY DEVELOPMENT						
Direct new development in a way that will minimize future rail/community conflicts.	X	X	X	X	X	X

KEY:

EV = Emergency Vehicle Delay
VS = Vehicular Safety
PS = Pedestrian Safety
AWS = Access to Work/School
ABS = Access to Personal Business/Social Activities
CD = Community Development
EN = Environment

Source: Minnesota DOT, 1980.

other coastal community, it may be possible to use barge transportation of bulk commodities on the final stage of the journey to ship. Several previous reports discuss the feasibility of barge transportation for coal to avoid New Bern and Morehead City rail conflicts (NCDNRCD, 1981; NCDOT, 1981). Also, slurry pipelines are another possible solution for transporting coal (NCDOT, 1982; Cribbins, 1982). However, intermodal transfer costs, in addition to the investments in capital required for barge or pipeline solutions, may be high. NCDOT estimates $2.00 to $4.00 per ton would be added to the cost of coal barged from New Bern. Rough estimates of slurry pipeline costs would be at least 10 to 14 cents per ton mile or about $1.00 to $1.40 for a 10-mile pipeline to bypass Morehead City (Funk, 1982). While these alternative modes have been examined for coal exports, their use for the shipment of other bulk commodities has not. It is expected, however, that barges and especially pipelines would have to be dedicated to a particular export commodity. They do not have the flexibility of railroads to handle a variety of import and export products. Recently, though, innovative work has shown that pneumatic pipelines may be adaptable to a variety of dry bulk commodities.

5.0 ANALYSIS OF ALTERNATIVE SOLUTIONS

This section of the report will match alternative solutions as discussed in Section 4.0 to the critical problem areas which were identified in Section 3.3. The results of this analysis represent potential solutions that should be explored prior to major rail traffic increases through the case study communities. Actual solutions will depend upon detailed design evaluations for individual grade crossings, as well as the overall community impacts which this report considered.

5.1 First-Step Solutions

Section 4.0 discussed high cost and low cost solutions to rail/community conflicts. Depending on the community, some solutions are appropriate; some not. For example, high cost grade separations, bypasses, and street widenings are needed in only a few critical situations. Some low cost solutions may or may not be appropriate for a particular community. Still others such as those in the following list should automatically be considered by policy-makers in all communities, as well as by state-level planners and policy-makers as a first step toward improvement:

1. Community Facility Changes
    a. Remove visual obstructions near crossings; maintain traffic control devices in good state of visibility.
    b. Close selected hazardous crossings.
    c. Install active warning devices at selected hazardous crossings.
    d. Upgrade and maintain pavement/rail alignment at "rough" crossings.
2. Community Service Changes
    a. Strictly enforce laws against crossing tracks when warning signals are activated.
    b. Reroute school buses, where feasible and practical within budget constraints, to avoid rail crossings.

   c. Designate alternative emergency vehicle routes.
   d. Redesign public transit routes where feasible and practical, to avoid hazardous crossings.
   e. Provide communication links between train crews and emergency service dispatchers.

3. Public Education and Public Relations

   a. Provide adult safety patrols for children crossing tracks.
   b. Conduct a public information campaign about rail crossing safety and rail transportation benefits.
   c. Conduct pedestrain safety programs in schools.
   d. Provide forums for public dialogue and communication between local communities and the railroads.

4. Community Development

   a. Plan new development to minimize rail/community conflicts.
   b. Modify city ordinances, where needed, to regulate train traffic.

5.2 Analysis of Problem-Specific Solutions

Assuming that the above solutions are equally applicable to all communities, seven problem-specific solutions were identified for further analysis, as follows:

1. Rail bypass
2. Grade separation
3. Street widening (more lanes, shorter queues)
4. Improved communications between approaching trains and emergency services so that alternate routes may be taken by responding vehicles.
5. Additional fire/medical services to protect isolated neighborhoods.
6. Active warning devices for grade crossing protection to reduce accidents (flashing lights, gates, and grade crossing predictors).
7. Ordinances to allow higher train speeds in order to reduce blocked crossing time.

These types of solutions are shown in Table 5-1 and are matched against the specific problems for each case study community.

TABLE 5-1

Potential Problem-Specific Solutions

Communities	Priority	Problems	Rail Bypass	Grade Separation	Street Widening	Improved Emergency Communications	Fire/Medical Service Expansion	Improved Grade Crossing Protection	Ordinance To Allow Higher Train Speeds
Rocky Mount	High								
	Med	MED, FED				X			
	Low	TD, GCA							
Wilson	High	TD, MED		X	X	X	X		X
	Med								
	Low	FED, GCA							
Goldsboro	High								
	Med	MED, FED, GCA				X		X	
	Low	TD							
Warsaw	High	MED				X	X		
	Med	GCA						X	
	Low	TD, FED							
Wilmington	High	FED				X			
	Med	TD, GCA		X				X	
	Low	MED							
Boiling Spring Lakes	High	TD, GCA						X	
	Med								
	Low	MED, FED							
Greenville	High								
	Med	TD, MED, FED				X			X
	Low	GCA							
New Bern	High	TD, FED, GCA	X			X		X	
	Med	MED				X			
	Low								
Kinston	High	FED				X			
	Med	TD, GCA						X	X
	Low	MED							
Morehead City *	High	TD, MED, GCA	X	X		X	X		
	Med	FED				X			
	Low								

Key:
FED = Fire Emergency Delays
MED = Medical Emergency Delays
TD = Traffic Delay and related impacts
GCA = Grade Crossing Accidents

*According to NCDOT (1982), railroad-highway grade separations at US 70 north of Newport ($4 million) and at SR 1177 east of Morehead City ($2.5 million) may be required depending on the rail bypass corridor chosen for Morehead City.

Summarizing the impact magnitudes described in Section 3.3, Table 5-1 shows that Rocky Mount, for example, will have relatively few problems associated with traffic delay and grade crossing accidents. Considering only the more pressing problems, Table 5-1 shows that Rocky Mount should consider improving future emergency service communications. Had the medical and fire delays been in the "high" category, fire/medical service expansion would have been recommended also. Similar interpretations can be made for the other recommended solutions.

In addition to the potential solutions suggested by Table 5-1, special socio-economic, environmental or cultural considerations beyond the scope of this report may dictate additional mitigation measures. For example, in New Bern the main line passes through the historic and business districts. As a consequence a bypass has been recommended if rail movements of coal exceed three million annual tons. (NCDOT, 1981).

5.3 Expected Costs

The costs of rail/community conflict mitigation measures are highly variable, however, the order of magnitude estimates listed in Table 5-2 can be made without detailed economic analysis. Actual costs depend on variable site requirements. Using the estimates in Table 5-2 and considering the types of future problems (Table 5-1) and existing grade crossing protection in the communities (Mallard, 1981), alternative mitigation measures and their approximate costs can be specified (Table 5-3).

5.4 Costs Versus Benefits

Table 5-3 suggests that for an additional 12 train movements to occur in each case study community, approximately $100 million worth of capital improvements must be made to alleviate rail/community comflicts. Breaking this figure down on a corridor basis, the north-south Wilmington route may require about $8 million. The Morehead City route through Goldsboro and Kinston may require about $65 million while going through Wilson and Greenville costs about $90 million.

Considering only the case study communities, which were evenly split between the port corridors, it would appear that promotion of the Wilmington route would be less costly in terms of rail/community grade crossing

TABLE 5-2

Order of Magnitude Cost Estimates

Solution Alternative	Capital Cost[1]	Operating & Maintenance Cost
Rail bypass	$50,000,000	$ -[2]
Grade separation (2 lane highway)	3,000,000	-
Street widening and traffic flow improvements	1,000,000	-
Emergency service/railroad communication system	1,000	100
Rescue squad (Volunteer squad)	25,000 (25,000)	25,000 (4,000)
Flashing lights	40,000	1,000
Lights and gates	100,000	2,000
Grade crossing predictors (train speed dependent signal timing)	80,000	1,000
Signal timing adjustments for higher train speeds	40,000	-

[1]Estimated 1982 costs

[2]Data not available

Sources: Minnesota DOT, 1980; North Carolina DOT, 1981, 1982; Nebraska, December, 1980.

TABLE 5-3 Estimated Cost of Solutions to Community Rail Impacts

City	Solutions	Cost: Itemized Capital	Cost: Itemized Annual	Cost: Total Capital	Cost: Total Annual
Rocky Mount				$ 1,000	$ 100
	1. Emergency service/RR communications system	$ 1,000	$ 100		
Wilson				8,446,000	30,100
	1. Grade separation (2)[1]	6,000,000			
	2. Street widening (2)[1]	2,000,000			
	3. Emer. svc./RR communications system	1,000	100		
	4. Rescue squad	25,000	25,000		
	5. Crossing predictors (5)[2]	300,000	5,000		
	6. Signal adjustments (3)[2]	120,000			
Goldsboro				701,000	15,100
	1. Emer. svc./RR communications system	1,000	100		
	2. Gates (4)[3,4]	240,000	4,000		
	3. Flashing lights (9)[3]	360,000	9,000		
	4. Lights & gates (1)[3]	100,000	2,000		
Warsaw				146,000	27,100
	1. Emer. svc./RR communications system	1,000	100		
	2. Rescue squad	25,000	25,000		
	3. Gates (2)[4]	120,000	2,000		

[1] Tarboro St., & Goldsboro St.

[2] GCP's (grade crossing protectors) applied to crossings w/gates. Crossings w/flashers are given signal timing adjustments for some set train speed.

TABLE 5-3 cont.

City	Solutions	Cost			
		Itemized		Total	
		Capital	Annual	Capital	Annual
Wilmington				$ 6,461,000	$ 8,000
	1. Grade separation (2)[5]	$ 6,000,000	$		
	2. Emer. svc/RR communications system	1,000	100		
	3. Gates (7)[3,4]	420,000	7,000		
	4. Flashing lights (1)[3]	40,000	1,000		
Boiling Spring Lakes				120,000	3,000
	1. Flashing lights (3)	120,000	3,000		
Greenville				181,000	1,100
	1. Emer. svc/RR communications system	1,000	100		
	2. Crossing predictors (1)[2]	60,000	1,000		
	3. Signal adjustments (3)[2]	120,000			
New Bern				55,321,000	7,100
	1. Emer. svc/RR communications system	1,000	100		
	2. Gates (2)[3]	120,000	2,000		
	3. Flashing lights (5)[3]	200,000	5,000		
	4. Bypass[6]	55,000,000			

[3]5000 ADT used as cutoff. Less than 5000 ADT implies flashers. Greater than 5000 ADT implies gates.

[4]Cost figure shown assumes that the cost of adding gates only (to crossings which already have flashers) is the difference between the cost of flashers only and the cost of both, or $60,000. O&M cost is also assumed to be the difference of the respective costs.

TABLE 5-3 cont.

City	Solutions	Cost			
		Itemized		Total	
		Capital	Annual	Capital	Annual
Kinston				$ 561,000	$ 12,100
	1. Emer. svc/RR communications system	$ 1,000	$ 100		
	2. Gates & crossing predictors (4)[2,3,4]	400,000	8,000		
	3. Flashing lights (4)[3]	160,000	4,000		
Morehead City				34,526,000	25,100
	1. Rail bypass[7]	28,000,000			
	2. Grade separations (2)[8]	6,500,000			
	3. Emer. svc/RR communications system	1,000	100		
	4. Rescue squad	25,000	25,000		
Total Costs				$106,464,000	$128,900

[5] Market St., & Oleander St.

[6] NCDOT design alternative.

[7] NCDOT (1982)

[8] US 70 at Newport and Sr 1177 east of Morehead City (NCDOT, 1982)

improvements. (This conclusion does not consider improvements that may be necessary at rural and small town grade crossings not considered by this study.) In return for $8 million in rail improvements (ignoring costs for port development, environmental concerns, etc.), roughly 300-350 jobs would be created (Section 3.1.1; 100 to 150 rail employees and 200 port employees). Assuming an average annual wage of $20,000 per new employee, $6 million in new annual payrolls would be created. Comparing a $8 million investment to capture $6 million in annual wages appears very attractive, but additionally, often non-quantifiable issues must be added to the decision process. Such a comparison will be left for future work.

REFERENCES

"Additional Coal Shipments Through Morehead City and New Bern: An Investigation of Alternate Methods and Routes. An Interim Report." North Carolina Department of Transportation, June 1982.

Andrews, R. B., Ph.D. "Treatment and Outcomes for Critical Patients, Preliminary Results." Emergency Medical Services, November/December 1978, p. 98.

AOV Industries. "Economic Impacts of Exporting Coal Through Morehead City." November 4, 1981.

"1980 Census of Population and Housing: Advance Reports." North Carolina PHC 80-V-35. U.S. Department of Commerce, Bureau of the Census.

"Coal Export in North Carolina." North Carolina Department of Natural Resources and Community Development, October 1981.

"Coal Train Movements Through the City of Wilmington." (Draft Report), Anderson and Associates, Inc., Blacksburg, Va., May 7, 1982.

Cribbins, P. D., and R. D. Latta. "Coastal Energy Transportation Study: Alternative Technologies for Transporting and Handling Export Coal." CEIP Report No. 12. NCDNRCD, Raleigh, North Carolina, 1982.

Funk, Edwin. Kamyr, Inc. Personal Communication, May 1982.

"Highway Traffic Statistics." NCDOT, Division of Highways, 1981.

"Impacts of Coal Trains on Nebraska Communities." Nebraska Department of Economic Development, Prepared by Wilbur Smith and Associates, October 1980.

Mallard, E. F. "The Impact of Unit Coal Trains on the North Carolina Grade Crossing Safety Program." N.C. Department of Transportation, September 1981.

Mallard, E. F. Personal Communication, July 1982.

Minnesota Department of Transportation and the North Dakota State Highway Department. "Alternative Solutions to Railroad Impacts on Communities." Volumes I, II, III. Prepared by Ernst and Whinney, 1980.

"NCDOH Pavement Condition Study: Primary Systems." NCDOT, September 3, 1982.

"North Carolina Insured Employment and Wage Payments." Employment Security Commission of North Carolina, 1978.

Powell, James L. "Effects of Rail-Highway Grade Crossings on Highway Users." Transportation Research Board Report 841, Washington, D.C., 1982, pp 22-28.

Silberman, J., and G. Yochum. "The Economic Impact of Virginia's Ports on the Commonwealth." School of Business Administration, Old Dominion University, Norfolk, Virginia, June 1980.

"16 Steps to Conserve Energy on N.C. Highways." North Carolina Energy Division.

Stone, J. R. "The Impacts of Coal Movements Through North Carolina." Presented at the Third Annual Conference on Urban Affairs, University of North Carolina, April 1981.

"Thoroughfare Plan for Rocky Mount, North Carolina." North Carolina Department of Transportation, 1973.

"Traffic Flow Theory." TRB Special Report 165, National Research Council, Washington, D.C., 1975.

"Port Economic Impact Kit." U.S. Department of Commerce. Maritime Administration. Prepared by Arthur D. Little, Inc., September, 1979.

"Wilmington Morning Star." Editorial. July 2, 1982.

APPENDIX A

RAILROAD GRADE CROSSING DELAY EQUATIONS FOR GENERAL HIGHWAY TRAFFIC

This appendix summarizes the equations to estimate the delays to vehicles at highway grade crossings. The train lengths considered are based on unit coal trains, however, the results are generally applicable to any train.

Blocked Crossing Time

Assumptions:

1. A future coal train will be composed of 100 100-ton cars, each 56.5 feet long, one 36-foot long caboose, and four 65.5-foot engines. The total length (L) is 5948 feet. (Near term operations have 70 to 75 cars pulled by three engines for a total length of 4470 feet.)
2. Signal activation time (S) is 30 seconds.
3. Signal cut-off time (S') is 5 seconds.
4. Train speed (V) is typically 10 miles per hour within city limits
5. Each crossing is blocked about 7 minutes per train as a result of 1-4.

Calculations:

$$BCT = S + S' + L/V$$

$$= \frac{30}{60} + \frac{5}{60} + \frac{5948}{52800/60}$$

$$= \underline{7.34 \text{ minutes}} \quad \text{(100 cars, 10 mph)}$$

2.52 minutes (100 cars, 35 mph)

5.66 minutes (75 cars, 10 mph)

10.57 minutes (75 cars, 5 mph)

2.62 minutes (75 cars, 25 mph)

20.3 minutes (145 cars at 5 mph)

Discussion:

Typical variations from the assumptions include shorter trains, longer signal activation times, and ranges of train speeds. The most sensitive term is the L/V term accounting for over 90% of the delay. For example, a 75-car train with three engines travelling 10 mph would block a crossing 5.66 minutes. A 100-car train travelling only 5 mph would block a crossing 14 minutes. It should also be mentioned that on many city streets of interest there are only signs to protect the grade crossing. The assumed value of activation time (30 seconds), however, is a safe approximation for the motorist's delay time before the train arrives at the crossing.

<u>Traffic Delay Time</u>

The traffic delay time depends on the blocked crossing time (BCT) and on the characteristics of the traffic flow. The delay time will be defined as the sum of the blocked crossing time and the time it takes for the queue to dissipate (i.e., the time for the traffic flow to return to normal).

Assumptions:

1. Crossings will be blocked by unit trains traveling 5 to 35 miles per hour depending on train speed limits.
2. Low volume coal operations at the level of three million tons annually will require one unit train per day (two daily train movements, one full and one empty).
3. For high volume coal operation (20 million tons annually) six unit trains per day or twelve daily train movements will be required. One train movement out of six will be assumed to move during a morning or evening peak traffic rush hour.
4. The peak hour traffic at a crossing will be taken as the average daily traffic (ADT) times a peaking factor derived from hourly traffic counts (NCDOT/DOH, 1981). Off-peak hour traffic is assumed to be one-half peak hour traffic.

5. For the downtown areas of the small and medium sized communities of concern, the peak and off-peak directional splits are 50%/50%.
6. The community streets where the railroad grade crossing occurs will, on the average, have a capacity of about 1000 vehicles per lane per hour for two-lane streets; 1500 vehicles per lane per hour for four-lane streets.

Calculations: (Traffic Flow Theory, 1975, p.165)

Duration of queue = $t_q = r(s-s_r)/(s-q)$

Number of vehicles affected = $N = qt_q$

Maximum number of vehicles in queue = Q_m

$$Q_m = r(q - s_r)$$

(Q_m does not include vehicles that arrive after the train leaves and the queue begins to slowly dissipate)

Total vehicle minutes of delay = $D = t_q Q_m/2$

Average minutes one vehicle is delayed = $d = (r/2)(1 - s_r/q)$

where: q= average arrival rate of traffic (vehicles/minute) upstream of crossing (per lane)

s= saturation flow rate or capacity (vehicles/minute) of uninterrupted flow (per lane)

s_r=flow rate (vehicles/minute) at crossing during blockage = 0 $(s_r < q < s)$

r= duration of blockage (minutes) = BCT

t_q=total elapsed time from start of blockage until normal flow resumes (minutes).

Results:

The following tables display the results of the traffic delay analysis. Tables A-1 to A-11 show the existing traffic impacts for urban and rural crossings when one train movement blocks the crossing during rush hour periods (peak hour values) or during non-rush hour periods (off-peak values). For each community all grade crossings were considered. Those picked for analysis had an average daily traffic volume of at least 2000 vehicles per day, plus they were on mainline corridors to one or both state ports.

Traffic and rail characteristics for each community or rural location are listed on the tables. All streets and roads are two-lane unless otherwise noted. Train lengths, speeds and movements were determined from averages compiled by the communities. Periods of operation, which often vary considerably from published schedule information, were also determined from community observations.

TABLE A-1 Current Rail/Highway Crossing Data for One Train Movement - Rocky Mount

Crossing Location	Crossing Number	Peak Hour Values[1]				Off-Peak Values[1]			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
NC 43 (E. Grand) (4 lanes)	SCL 630 082X	1583	3.4	90	113	791	2.9	38	48
US 64 West (Thomas St., one-way, 3 lanes)	SCL 630 084L	1729	4.1	117	147	864	3.1	45	56
US 64 East (Sunset Ave. one-way, 3 lanes)	SCL 630 085T	1702	4.0	115	144	851	3.1	44	55
Bassett Street	SCL 629 767F	968	4.9	78	98	484	3.3	27	34
TOTALS			16.4	400	502		12.4	154	193

Rail Operations

100-car train at 35 mph.
16 trains per day; 3 during peak hours, 13 during off-peak hours.
6 SCL non-port-corridor crossings omitted.
26 crossings with ADT less than 2000 omitted.

[1]Values presented are for one train blockage during peak or off-peak hour

TABLE A-2 Current Rail/Highway Crossing Data for One Train Movement - Wilson

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Park Ave.	NS 465 605W	264	8.5	37	136	132	7.9	17	63
Barnes St.	SCL 629 850G	550	3.5	32	40	275	2.9	13	17
Nash St.	SCL 629 851N	770	4.1	52	66	385	3.1	20	25
Green St.	SCL 629 849M	385	3.1	20	25	193	2.8	9	11
Forest Hills Blvd. (SR 1183)	NS 465 611A	495	9.8	40	148	248	8.4	17	64
Tarboro St. (SR 1184)	NS 465 604P	1419	25.3	597	2192	710	11.4	135	494
Goldsboro St. (SR 1163)	NS 465 602B	957	14.1	224	824	479	9.7	77	283
Wilco Blvd. (SR 1608)	SCL 629 866D	231	2.8	11	14	115	2.7	5	6
Stantonsburg Rd. (SR 1602)	NS 465 592X	220	8.2	30	111	110	7.8	14	52
Black Creek Rd. (SR 1606)	NS 465 597G	473	9.6	76	278	236	8.3	33	120
Herring Ave. (SR 1163)	SCL 629 847Y	858	4.4	63	79	429	3.2	23	29
E. Vance St. (SR 1369)	SCL 629 848F	308	3.0	15	19	154	2.7	7	9
TOTALS	SOU		83.0	1011	3714		60.9	296	1089
	SCL		20.9	193	243		17.4	77	97

Rail Operations

SCL trains average 100 cars, 35 mph.
SOU trains average 100 cars, 10 mph.
SOU has 5 trains per day; 1 during peak hour, 3 during off-peak hours.
SCL had 18 trains per day; 1 passenger train during the peak hours and 3 during off-peak hours.
2 freight trains during the peak hours and 12 during off-peak hours.

TABLE A-3 Current Rail/Highway Crossing Data for One Train Movement - Goldsboro

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
US 133-117 Bypass (4 lanes)	SOU 733 307T	2102	6.1	214	425	1051	4.8	84	167
West Ash Street	SOU 733 304X	706	6.1	72	143	353	4.8	28	56
Oak Street	SOU 628 585R	232	4.5	17	34	116	4.2	8	16
George St.(US 70 bus)	SOU 735 301C	698	6.1	71	141	349	4.8	28	56
James Street	SOU 735 296H	366	4.9	30	59	183	4.4	13	26
Holly Street	SOU 722 879G	312	4.7	24	49	156	4.3	11	22
North John Street	SOU 722 877T	295	4.7	23	45	147	4.3	10	21
North William St. (US 117 Bus.)	SOU 722 876L	809	6.7	90	178	405	5.0	34	67
Lionel Street	SOU 722 872J	312	4.7	24	49	156	4.3	11	22
Snowhill Rd.(SR 1556)	SOU 722 870V	186	4.4	14	27	93	4.2	6	13
North Audubon Ave.	SOU 722 869B	196	4.4	14	29	98	4.2	7	14
Jefferson St.	SOU 722 868U	464	5.2	40	79	232	4.5	17	34
TOTALS			62.5	633	1258		53.8	257	514
(continued)									

Goldsboro - cont.

Crossing Location	Crossing Number	Peak Hour Values: Approach Volume (veh/hr)	Peak Hour Values: Queue Duration (min)	Peak Hour Values: Affected Vehicles (veh)	Peak Hour Values: Total Delay (veh-min)	Off-Peak Values: Approach Volume (veh/hr)	Off-Peak Values: Queue Duration (min)	Off-Peak Values: Affected Vehicles (veh)	Off-Peak Values: Total Delay (veh-min)
West Elm Street	SCL 628 591U	268	4.6	20	41	134	4.3	10	19
West Ash Street	SCL 628 586X	707	6.1	72	144	353	4.8	28	56
Holly Street	SCL 628 584J	223	4.4	17	33	112	4.2	8	16
TOTALS			15.1	109	218		13.3	46	91

Rail Operations

Averages of 75 cars and 15 mph were used for Southern and SCL operations.
Southern: 2 through trains during off-peak hours.
SCL: 2 through trains during off-peak hours.
Switching operations occur continuously and were not analyzed.
18 crossings with ADT less than 2000 omitted.

TABLE A-4 Current Rail/Highway Crossing Data for One Train Movement - Warsaw

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Hill Street (SR 1340)	SCL 628 894D	420	3.3	23	30	210	2.9	10	13
College Street (NC 24)	SCL 628 892P	389	3.3	21	28	194	2.8	9	12
TOTALS			6.6	44	58		5.7	19	25

Rail Operations

3 trains per day during off-peak hours.
75-car trains at 25 mph.
6 crossings with ADT less than 2000 omitted.

TABLE A-5 Current Rail/Highway Crossing Data for One Train Movement - Wilmington

Crossing Location	Crossing Number	Peak Hour Values[1] Approach Volume (veh/hr)		Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Off-Peak Values[1] Approach Volume (veh/hr)		Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
		NB[2]	SB[2]				NB[2]	SB[2]			
23rd	SCL 629 286M	616	420	11.8	176	399	308	210	6.5	54	121
30th	SCL 629 287U	282	250	6.3	55	124	141	125	5.3	23	52
Princess Place	SCL 629 288B	522	347	9.5	123	278	261	174	6.1	43	96
Market (4 lanes)	SCL 629 290C	1347	757	8.2	260	594	674	379	5.8	98	222
Covil	SCL 629 426M	93	93	5.0	16	36	47	47	4.7	8	16
Forest Hill	SCL 629 428B	240	204	6.0	48	108	120	120	5.1	20	46
Colonial	SCL 629 429H	100	340	6.9	47	107	50	170	5.4	19	44
Wrightsville (4 lanes)	SCL 629 430C	541	974	6.7	158	358	271	487	5.4	66	150
Oleander (4 lanes)	SCL 629 431J	1200	1403	8.5	350	792	600	701	5.9	124	284
17th (one-way)	SCL 629 432R	1002	-	9.1	76	171	501	-	6.0	25	57
16th	SCL 629 433X	-	931	8.5	66	149	-	465	5.9	23	52
13th (one-way)	SCL 629 435L	220	220	5.8	21	48	110	110	5.1	9	21
5th	SCL 629 442W	130	130	5.2	11	26	65	65	4.8	10	24
3rd (4 lanes)	SCL 629 446Y	616	484	5.7	102	232	308	242	5.1	46	104
Front	SCL 629 448M	502	301	9.1	109	247	251	150	6.0	38	87
TOTALS				112.3	1618	3669			83.1	606	1376

Railroad Operations

4000 foot trains at 10 mph.
2 trains per day during off-peak hours.
Crossings selected to correspond with Anderson Assoc. Report, 1982

[1]Values correspond with Anderson and Assoc., 1982

[2]NB = North Bound; SB = South Bound

TABLE A-6 Rail/Highway Crossing Data for One Train Movement - Boiling Spring Lakes

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Military Traffic									
Boiling Springs Road	875 050V	54	2.8	3	4	27	2.8	1	2
Apache Road	310 657J	11	2.8	1	0	5	2.8	0	0
50 Lakes Drive	310 656C	49	2.8	2	3	24	2.8	1	2
TOTALS			8.4	6	7		8.4	2	4
Potential Freight Traffic									
Boiling Springs Road	875 050V	54	7.5	7	25	27	7.4	3	12
Apache Road	310 657J	11	7.4	1	5	5	7.4	1	2
50 Lakes Drive	310 656C	49	7.5	6	22	24	7.4	3	11
TOTALS			22.4	14	52		22.2	7	25

Rail Operations

Military Traffic: 2 trains, 15 cars, 5 mph, off-peak operation.

Potential Traffic: 12 trains, 100 cars, 10 mph, peak and off-peak.

TABLE A-7 Current Rail/Highway Crossing Data for One Train Movement - Greenville

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
US 13/NC 11-43-903 (4 lanes)	NS 465 512C	1631	7.8	211	598	815	6.5	89	252
Line Avenue	NS 465 511V	378	7.0	44	124	189	6.3	20	56
Skinner Street	NS 465 509U	324	6.8	36	103	162	6.2	17	47
Beatty Street	NS 465 506Y	378	7.0	44	124	189	6.3	20	56
Pitt Street	NS 465 496V	378	7.0	44	124	189	6.3	20	56
Evans Street (SR 1702)	NS 465 495N	809	9.5	128	363	404	7.1	48	135
West Berkley Road	NS 465 492T	324	6.8	36	103	162	6.2	17	47
Elm Street (4 lanes)	NS 465 491L	540	6.2	56	158	270	5.9	27	75
Brownlea Drive	NS 465 490E	378	7.0	44	124	189	6.3	20	56
US 264 Bypass	NS 465 489K	1328	7.3	161	455	664	6.4	70	199
SR 1704	NS 465 488D	583	8.0	78	220	292	6.6	32	91
SR 1726	NS 465 482M	270	6.5	29	83	135	6.1	14	39
TOTALS			86.9	911	2579		76.2	394	1109

Rail Operations

75-car trains, 10 mph.
SOU: 4 trains per day, 1 peak, 3 off-peak.
2 crossings with ADT less than 2000 omitted.
15 SCL non-port-corridor crossings omitted.

TABLE A-8 Current Rail/Highway Crossing Data for One Train Movement - New Bern

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
N. Craven/Dunn	NS 466 045V	182	6.2	19	53	91	5.9	9	25
Queen/Hancock	SOU 722 704D	128	6.0	13	37	64	5.8	6	18
Johnson/Hancock	SOU 722 703W	107	6.0	11	30	54	5.8	5	15
New/Hancock	SOU 722 702P	107	6.0	11	30	54	5.8	5	15
Broad/Hancock(4 lanes)	SOU 722 701H	2461	9.6	394	1114	1230	7.1	146	413
Pollock/Hancock	SOU 722 700B	803	9.5	126	358	401	7.1	47	134
Try. Pal. Dr./Hancock	SOU 722 699J	471	7.4	58	164	235	6.4	25	71
TOTALS			50.7	632	1786		43.9	243	691

Railroad Operations

75-car trains, 10 mph.
4 trains per day average; 1 peak, 3 off-peak.
21 non-port-corridor crossings omitted.

TABLE A-9 Current Rail/Highway Crossing Data for One Train Movement - Kinston

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Vernon Ave. (4 lanes)	SOU 722 810L	955	6.7	107	303	477	6.1	49	138
Dewey Street	-	344	6.8	39	111	172	6.2	18	50
Mitchell Street	SOU 722 796L	310	6.7	35	98	155	6.1	16	45
Peyton Street	SOU 722 795L	293	6.6	32	92	146	6.1	15	42
Herritage Street	SOU 722 794E	863	10.0	143	405	432	7.2	52	147
Queen Street	SOU 722 793X	1503	7.6	189	535	752	6.5	81	230
Caswell Street	SOU 722 781D	248	6.5	27	76	124	6.0	12	35
King Street	SOU 722 780W	724	6.4	78	220	362	6.0	36	103
Tiffany & Bright St.	SOU 722 779C	455	7.3	56	157	227	6.4	24	68
TOTALS			64.6	706	1997		56.6	303	858

Railroad Operations

75-car train at 10 mph.
2 Southern trains per day; off-peak.
4 SCL trains per day; 1 peak, 3 off-peak.
8 crossings with ADT less than 2000 omitted.
3 non-port-corridor crossings omitted.

TABLE A-10 Current Rail/Highway Crossing Data for One Train Movement - Morehead City

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
West Bound US 70 just west of SR 1176 (2 lanes)	SOU 722 643P	1581	22.3	588	3112	791	14.4	189	1000
East Bound US 70 just west of SR 1176	SOU 722 632C	1480	20.9	514	2720	740	14.0	173	915
North Bound 24th St. traffic turning left to West US 70	SOU 722 611J	828	61.4	847	4478	414	18.0	124	658
South Bound 24th St. traffic turning left from West US 70	SOU 722 611J	422	18.3	129	679	211	13.4	47	249
TOTALS			122.9	2078	10989		59.8	533	2822

Railroad Operations

75-car trains at 5 mph.
2 trains per day at variable hours
25 minor crossings omitted.

TABLE A-11 Current Rural Rail/Highway Crossing Data for One Train Movement

Crossing Location[1]	Crossing Number	Peak Hour Values[2]				Off-Peak Values[2]			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
Brunswick Co.	310 655V	349	2.0	12	10	174	1.8	5	4
Carteret Co.									
SR 1247 Chatham St.	SOU 722 664H	466	3.4	27	35	233	3.0	12	15
US 70	SOU 722 672A	1548	3.5	23	30	744	3.0	10	13
SR 1177	SOU 722 649F	290	3.1	15	19	145	2.8	7	9
Craven Co.									
NC 55	SOU 722 711N	1081	6.9	124	352	540	6.2	56	158
SR 1402	SOU 722 710G	690	8.6	99	281	345	6.8	39	111
SR 1215	SOU 722 709M	540	7.8	70	197	270	6.5	29	83
US 17 Bypass	NS 466 092D	282	3.0	14	19	141	2.8	7	9
SR 1616	NS 466 051Y	235	3.0	12	15	118	2.8	5	7
US 17	NS 466 041T	824	4.5	61	80	412	3.3	23	30
SR 1745 & SR 1756	SOU 722 674N	578	8.0	77	217	289	6.6	32	90
Duplin Co.									
NC 403/50	SCL 628 815P	315	3.1	16	21	158	2.8	7	10
SR 1173	SCL 628 652H	368	3.2	20	26	184	2.9	9	12
NC 41 (W. Main St.)	SCL 628 653P	598	2.9	29	38	299	2.8	14	18
Halifax Co.									
SR 1641	SCL 629 654A	545	3.4	31	39	273	2.9	13	17
NC 125/903	SCL 629 659J	346	3.0	18	22	173	2.7	8	10
NC 481	SCL 629 670J	359	3.1	18	23	180	2.8	8	10
Lenoir Co.									
SR 1546	SOU 722 825B	216	2.9	11	14	108	2.8	5	7
US 258	SOU 722 822F	622	3.8	39	52	311	3.1	16.	21
Nash Co.									
NC 231	NS 465 640K	330	3.1	17	23	165	2.9	8	10
NC 44	SCL 629 679V	319	3.0	16	20	160	2.7	7	9
(continued)									

TABLE A-11 Current Rural Rail/Highway Crossing Data for One Train Movement - cont.

Crossing Location	Crossing Number	Peak Hour Values				Off-Peak Values			
		Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)	Approach Volume (veh/hr)	Queue Duration (min)	Affected Vehicles (veh)	Total Delay (veh-min)
New Hanover Co.									
SR 1318	SCL 628 1318	273	3.0	14	18	137	2.8	6	8
SR 1322	SCL 628 716S	657	3.9	43	56	328	3.1	17	22
SR 1302	SCL 628 721N	813	4.4	60	78	407	3.3	22	29
Northampton Co.									
NC 46	SCL 629 643M	466	3.3	25	32	233	2.8	11	14
Pender Co.									
NC 53	SCL 628 683G	461	3.4	26	34	230	3.0	11	15
NC 210	SCL 628 695B	206	2.9	10	13	103	2.8	5	6
Pitt Co.									
US 264	NS 465 544H	616	2.9	30	39	308	2.8	14	19
US 258	NS 465 540F	464	3.4	26	35	232	3.0	11	15
US 264A	NS 465 535J	270	3.0	14	18	135	2.8	6	8
Wayne Co.									
US 13	SOU 722 861W	530	5.4	48	95	265	4.6	20	40
Wilson Co.									
NC 58	NS 465 577V	385	3.2	21	28	192	2.9	5	6

[1]Only crossings with ADT greater than 2000 considered.

[2]Values presented are for one train blockage during peak or off-peak hour.

APPENDIX B

GRADE CROSSING CONFLICTS FOR EMERGENCY SERVICE RESPONSES

Estimated Medical Emergency Delays and Route Deviations

Medical emergency delays will occur if volunteers are delayed on their way to the ambulance as well as when the ambulance travels to the emergency location or to the hospital. The analysis predicts the sum of the expected values of vehicle and volunteer delays at blocked crossings, plus route deviations to avoid blocked crossings. Equations for the composite delays and route deviations are listed below, and they are based on the methods found in the 1980 reference for the Minnesota DOT.

MED = MVD + AD where:

MED = estimated medical emergency delays per year

MVD = delays to medical volunteers on the way to the ambulance station per year.

= PVC(PD)(ME)

PD = probability of being delayed

= BCT/24

ME = average number of medical emergencies per year

BCT = blocked crossing time

PVC = probability that <u>at least one</u> volunteer must cross the tracks on the way to the ambulance station.

AD = potential number of delays to reponding ambulances on the way to the emergency plus going to the hospital

= EAC(PD)

EAC = estimated ambulance crossings per year

= ME(PCT) or 2(ME)(PCT) if both ambulance and hospital are on the same side of the tracks.

ME = average number of medical emergencies per year

PCT = probability that the tracks must be crossed.

Values for the medical emergencies experienced by the community are provided by the community, as well as their geographic distribution, location of responding ambulances, volunteers, etc. In case the average number of medical emergencies is unavailable, a rule of thumb is that there is one response per day per 5000 people in the service area. The probability of being delayed (PD) is the ratio of the total blocked crossing time per day divided by 24 hours. The total blocked crossing time is found by dividing the track section length with no overpasses being considered by the train speed. Since a train will typically block many more than one crossing at a time, an adjustment is made by multiplying by the ratio of train length to track section length. The result is BCT as defined by Appendix A.

The following example shows how the probability of a volunteer (PVC) being delayed is calculated.

Let $PVC = \sum_i P_i(x)$

where $P_i(x)$ = probability of a particular volunteer team i composition.

For example, assume the following situation:

A community (service zone) has 26 volunteers.

The ambulance station is on the south side of the tracks.

17 volunteers live or work north of the tracks; 9 south of the tracks.

3 volunteers make up a team.

Possible combinations of n volunteers from the opposite side taken x at a time.

${}_nC_x = n!/x!(n-x)!$

Volunteer Location		
South	North	${}_nC_x$
3	0	1
2	1	3
1	2	3
0	3	1

The probability of the team combinations are $P_i(x) = {}_nC_x \pi_j p_j$

where: p_j = the dependent probabilities of the team members coming from one or the other side of the track.

For the example community we have:

Volunteer Location		$_nC_x$	x Team Member Probabilities $(\Pi_j p_j)$	=	Team Probabilities $(P_i(x))$
South	North				
3	0	1	(9/26)(8/25)(7/24)	=	0.032
2	1	3	(9/26)(8/25)(17/24)	=	0.235
1	2	3	(9/26)(17/25)(16/24)	=	0.471
0	3	1	(17/26)(16/25)(15/24)	=	0.262
					1.000

Thus, the probability that at least one volunteer must cross the tracks and delay the emergency medical response is:

$PVC = \Sigma_i P_i(x) = 0.235 + 0.471 + 0.262 = 0.968.$

And if the community had 120 medical emergencies per year on the average and the probability of being delayed is 0.104 (= BCT/24 = 2.496/24)

then $VD = PVC(PD)(ME) = 0.968(.104)(120)$

$VD = 12.08$ = annual number of volunteers delayed on the way to the ambulance station.

Estimated Fire Emergency Delays and Route Deviations

The calculation of delays and route deviations for responding fire equipment is analogous to that of ambulances except once a fire vehicle reaches the site of the fire it stays there. It does not have to then travel to a hospital and risk another delay. In case information on the average number of fire responses per year is unavailable, a rule of thumb is that one fire response is made per day per 1000 people in the service area. The following equations describe the procedure.

FED = FVD + FTD

FED = estimated fire emergency delays per year

FVD = delays to fire volunteers on the way to the fire station (number/year)

= FE(PVC)(PD)

FE = average number of fire calls per year

PVC = probability of at least one volunteer having to cross the tracks on the way to the fire station.

PD = probability of being delayed.

FTD = delays to the firetruck on the way to the fire (number/year)

= FE(PCT)(PD)

PCT = percentage of the population on the side of the tracks opposite the fire station.

FE = number of fire responses per year.

Estimated Police Emergency Delays

Rather than being located in stationary locations as are fire and ambulance services, police vehicles patrol throughout a community. Thus, it can be assumed at any particular time that police vehicles will be located on both sides of any railroad tracks, and, hence, there will be negligible delay in responding to emergencies.

Future Traffic Delay Time (Future BCT)

The future blocked crossing time will be a function of future train traffic, length, and speed, as well as future signal activation times. For simplicity, only future train traffic increases were considered in Section 3.2.1.

Future Fire and Medical Emergency Delays

These future estimates are made by projecting the number of emergency calls (a function of population change), the location of the calls (a function of the future service area population distribution on either side of the tracks), and the amount of time crossings will be blocked on the average day (a function of the future train traffic). If it is assumed that population distribution in the community remains approximately the same, then future delays will not vary as a function of distribution changes. In the last 10 years population growth for North Carolina communities has averaged 16%, a trend expected to continue in the future. However, in the case study area, future train traffic may increase from 50% to 600%. Hence, the major effect is train traffic and only future train traffic increases were considered in estimating future fire and medical response conflicts.

APPENDIX C

GRADE CROSSING ACCIDENT MODELS

The accident models presented in Table C-1 were used to establish an estimate of expected vehicle accidents per year at grade crossings. Because the equations are based on national data, and due to the difficulty associated with estimating grade crossing accidents in general, the estimates of expected accidents for the case study communities must be regarded as representing only the order of magnitude of what may actually occur.

These models have been designed for use in looking at the accident potential for individual grade crossings, the values for each factor being chosen on the basis of the characteristics of a particular grade crossing. For the purposes of this study, however, values were instead chosen to represent the community as a whole. For each community, all crossings having a common type of protection were considered together in one equation. In communities having two potential coal corridors, the impact of each corridor was considered separately.

Hazard index (HI) values for a specific community were determined by observing the change in HI as a function of ADT over the approximate range of ADT values that would be expected for individual crossings, and extrapolating linearly to an ADT value representing the total for the community. Values which were constant for a specific community or corridor, such as population and number of main track, were inserted directly into the formulas in Table C-1. Values for remaining factors were chosen so as to represent an average for the community.

It should be noted that the method of analysis used yields conservative accident estimates, largely the effect of the HI values derived.

TABLE C-1

Equations Used To Estimate Accidents Per Year at Rail-Highway Grade Crossings

(Minnesota DOT, 1980)

EQUATIONS
° For passive protection EA = HI*DT*MT*HP*P*FC
° For flashing lignts protection EA = HI*DT*MT*L*P*FC
° For automatic gates protection EA = HI*MT*L

VARIABLES
DT = number of day through trains on average
EA = estimated number of accidents per year
FC = highway functional classification
HI = basic hazard index, a function on trains per day and annual average daily traffic
HP = highway pavement
L = number of highway lanes
MT = number of main tracks
P = population of the community in which the crossing is located

TABLE C-2

VALUES FOR VARIABLES USED IN THE PASSIVE PROTECTION FORMULA

HI = TOTAL TRAINS PER DAY	ANNUAL AVERAGE DAILY HIGHWAY TRAFFIC												
	1-100	101-300	301-500	501-700	701-900	901-1500	1501-3000	3001-5000	5001-7000	7001-9000	9001-15000	15001-30000	>30000
<1	.02	.02	.03	.03	.03	.04	.04	.06	.06	.07	.08	.10	.14
1	.02	.03	.04	.05	.05	.06	.08	.10	.11	.12	.14	.17	.23
2	.02	.04	.06	.07	.07	.08	.10	.13	.15	.16	.18	.21	.27
3	.03	.05	.07	.08	.09	.10	.12	.15	.17	.19	.21	.24	.30
4	.03	.06	.08	.09	.10	.12	.14	.17	.20	.21	.24	.27	.32
5	.03	.07	.09	.10	.11	.13	.16	.19	.21	.23	.25	.28	.33
6	.04	.08	.10	.11	.12	.14	.17	.20	.23	.24	.27	.29	.33
7	.04	.08	.11	.12	.13	.15	.18	.22	.24	.26	.28	.30	.34
8	.04	.09	.11	.13	.14	.16	.19	.23	.25	.27	.29	.31	.34
9	.04	.09	.12	.14	.15	.17	.20	.24	.26	.27	.30	.32	.34
10	.05	.10	.12	.14	.16	.18	.21	.24	.27	.29	.30	.32	.34
11-20	.06	.12	.15	.17	.18	.20	.24	.27	.30	.31	.32	.34	.33
21-40	.07	.15	.19	.21	.22	.25	.28	.31	.33	.33	.34	.34	.31
41-60	.08	.17	.21	.23	.25	.27	.30	.33	.34	.34	.34	.33	.28
61-80	.09	.19	.23	.25	.27	.29	.31	.33	.34	.34	.34	.33	.27
81-100	.10	.20	.24	.26	.27	.29	.32	.34	.34	.34	.34	.32	.26
>100	.10	.20	.24	.26	.28	.30	.32	.34	.34	.34	.33	.32	.25

DT =	1.00	1.12	1.20	1.26	1.31	1.35	1.39	1.42	1.45	1.48	1.50	1.60	1.74	1.83	1.94
where no. of day through trains is	0	1	2	3	4	5	6	7	8	9	10	11-20	21-30	31-40	>40

FC =	0.77	0.59	0.45	0.35	0.27	0.21
where the class is[a]	Interstate	Expressway	Principle Arterial	Minor Arterial	Collector	Local

MT =	1.00	1.42	2.01	2.86	4.05	5.75
where no. of main tracks is	0	1	2	3	4	5

HP =	1.43	1.00
where highway is	paved	not paved

P =	1.00	1.10	1.20	1.31	1.44
where population is[a]	<5,000	5-10,000	10-25,000	25-50,000	>50,000

[a] Obtained from code for the functional classification of the highway. FC is determined by the units digit of the code. P is determined by the tens digit.

Source: Worksheet provided by the Office of Research, Federal Highway Administration.

Minnesota DOT, 1980.

TABLE C-3

VALUES FOR VARIABLES USED IN THE FLASHING LIGHTS PROTECTION FORMULA

	1-100	101-300	301-500	501-700	701-900	901-1300	1301-1700	1701-2100	2101-2500	2501-3000	3001-4000	4001-5000	5001-6000	6001-7000	7001-8000
<1	.00	.01	.01	.01	.01	.02	.02	.02	.02	.02	.03	.03	.03	.04	.04
1	.01	.01	.02	.02	.02	.02	.03	.03	.03	.04	.04	.05	.05	.06	.06
2	.01	.02	.02	.02	.03	.03	.03	.04	.04	.05	.05	.06	.07	.07	.08
3	.01	.02	.02	.03	.03	.04	.04	.05	.05	.06	.06	.07	.08	.09	.10
4	.01	.02	.03	.03	.03	.04	.05	.05	.06	.06	.07	.08	.09	.10	.11
5	.01	.02	.03	.03	.04	.04	.05	.06	.06	.07	.08	.09	.10	.11	.12
6	.01	.02	.03	.04	.04	.05	.06	.06	.07	.08	.09	.10	.11	.12	.13
7	.01	.03	.04	.04	.04	.05	.06	.07	.07	.08	.09	.10	.12	.13	.14
8	.01	.03	.04	.04	.05	.06	.06	.07	.08	.09	.10	.11	.12	.14	.15
9	.01	.03	.04	.04	.05	.06	.07	.08	.08	.09	.10	.12	.13	.14	.16
10	.01	.03	.04	.05	.05	.06	.07	.08	.09	.10	.11	.12	.14	.15	.16
11-15	.02	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12	.14	.16	.17	.18
16-20	.02	.04	.05	.06	.07	.08	.09	.10	.11	.13	.14	.16	.18	.20	.21
21-25	.03	.04	.06	.06	.07	.09	.10	.11	.13	.14	.16	.18	.20	.22	.24
26-30	.03	.05	.06	.07	.08	.10	.11	.12	.13	.15	.17	.19	.22	.24	.26
31-40	.03	.05	.07	.08	.09	.11	.12	.14	.15	.17	.19	.22	.24	.27	.29
41-60	.04	.06	.08	.09	.11	.12	.14	.16	.17	.19	.21	.25	.28	.30	.33
61-80	.04	.07	.09	.11	.12	.14	.16	.18	.20	.22	.24	.28	.31	.34	.37
81-100	.05	.08	.10	.12	.13	.15	.17	.19	.21	.24	.27	.31	.34	.37	.41
>100	.05	.08	.10	.12	.14	.16	.18	.20	.22	.25	.28	.32	.35	.39	.42

	8001-9000	9001-10000	10001-12000	12001-14000	14001-16000	16001-18000	18001-20000	20001-24000	24001-28000	28001-32000	32001-40000	40001-50000	>50000
<1	.04	.05	.05	.06	.06	.07	.07	.08	.09	.10	.11	.13	.18
1	.07	.07	.08	.09	.10	.10	.11	.12	.14	.15	.17	.20	.29
2	.09	.09	.10	.11	.12	.13	.14	.16	.17	.19	.22	.25	.37
3	.10	.11	.12	.13	.15	.16	.17	.19	.21	.23	.26	.30	.43
4	.12	.12	.14	.15	.16	.18	.19	.21	.24	.26	.29	.34	.49
5	.13	.14	.15	.17	.18	.20	.21	.23	.26	.29	.32	.38	.55
6	.14	.15	.16	.18	.20	.21	.23	.25	.28	.31	.35	.41	.59
7	.15	.16	.18	.19	.21	.23	.25	.27	.30	.33	.38	.44	.64
8	.16	.17	.19	.20	.23	.25	.26	.29	.32	.36	.40	.47	.68
9	.17	.18	.20	.21	.24	.26	.28	.31	.34	.38	.43	.50	.72
10	.18	.19	.21	.23	.25	.27	.29	.32	.36	.39	.45	.52	.75
11-15	.20	.21	.23	.27	.28	.31	.33	.36	.40	.44	.50	.58	.85
16-20	.23	.25	.27	.30	.33	.35	.38	.42	.47	.51	.58	.68	.98
21-25	.26	.27	.30	.33	.36	.39	.42	.47	.52	.57	.65	.76	1.09
26-30	.28	.30	.33	.36	.40	.43	.46	.51	.57	.62	.70	.82	1.19
31-40	.31	.33	.36	.40	.44	.48	.51	.56	.63	.69	.78	.91	1.32
41-60	.35	.38	.41	.46	.50	.54	.58	.64	.71	.79	.89	1.04	1.50
61-80	.40	.43	.47	.52	.57	.61.	.66	.73	.81	.89	1.01	1.18	1.70
81-100	.44	.47	.51	.57	.62	.67	.72	.79	.89	.98	1.10	1.29	1.80
>100	.46	.49	.53	.59	.64	.70	.75	.82	.92	1.01	1.15	1.34	1.90

DT =	1.00	1.08	1.12	1.16	1.18	1.21	1.23	1.24	1.26	1.27	1.29	1.34	1.41	1.46	1.51
where no. of day through trains is	0	1	2	3	4	5	6	7	8	9	10	11-20	21-30	31-40	>40

MT =	1.00	1.32	1.73	2.28	3.00	3.95	5.20
where no. of main tracks is	0	1	2	3	4	5	>5

L =	1.04	1.07	1.11	1.16	1.20	1.24	1.29	1.34	1.38
where lane is	1	2	3	4	5	6	7	8	>8

P =	1.00	1.04	1.08	1.12	1.16
where population is*	>5	5-10	10-25	25-50	>50

FC =	0.93	0.87	0.80	0.75	0.70	0.65
where the class is*	Interstate	Express	Principal Arterial	Minor Arterial	Collector	Local

* Obtained from code for the functional classification of the highway. FC is determined by the units digit of the code. P is determined by the tens digit.

TABLE C-4

VALUES FOR VARIABLES USED IN THE AUTOMATIC GATES PROTECTION FORMULA

	ANNUAL AVERAGE DAILY HIGHWAY TRAFFIC														
TOTAL TRAINS/DAY	1-100	101-300	301-500	501-700	701-900	901-1500	1501-3000	3001-5000	5001-7000	7001-9000	9001-13000	13001-20000	20001-30000	30001-50000	>50000
HI = <1	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008	.008
1	.009	.010	.010	.010	.010	.010	.011	.011	.011	.011	.011	.012	.012	.012	.012
2	.010	.011	.011	.012	.012	.012	.013	.013	.013	.014	.014	.014	.015	.015	.016
3	.010	.012	.013	.013	.013	.014	.014	.015	.015	.016	.016	.017	.017	.018	.019
4	.010	.013	.013	.014	.014	.015	.015	.016	.017	.017	.018	.019	.019	.020	.021
5	.011	.013	.014	.015	.015	.016	.017	.018	.018	.019	.019	.020	.021	.022	.023
6	.011	.014	.015	.016	.016	.017	.018	.019	.020	.020	.021	.022	.023	.024	.025
7	.011	.014	.016	.016	.017	.018	.019	.020	.021	.022	.022	.023	.025	.026	.027
8	.011	.015	.016	.017	.018	.018	.020	.021	.022	.023	.023	.024	.026	.028	.020
9	.011	.015	.017	.018	.018	.019	.021	.022	.023	.024	.025	.026	.028	.029	.030
10	.011	.016	.017	.018	.019	.020	.021	.023	.024	.025	.026	.027	.029	.031	.033
11-20	.012	.018	.019	.021	.021	.023	.025	.027	.029	.030	.031	.033	.035	.038	.040
21-40	.015	.021	.024	.026	.027	.029	.032	.036	.040	.041	.043	.046	.050	.055	.060
41-60	.016	.024	.028	.030	.032	.035	.040	.045	.050	.052	.055	.059	.066	.072	.080
61-80	.016	.027	.031	.034	.036	.040	.045	.052	.059	.061	.065	.071	.078	.087	.100
81-100	.016	.028	.034	.037	.040	.043	.050	.058	.066	.068	.073	.081	.089	.100	.110
>100	.017	.029	.035	.038	.041	.045	.052	.061	.069	.072	.077	.085	.093	.106	.120
L =	1.21	1.46	1.76	2.12	2.56	3.08	3.72	4.49	5.42						
where no. of highway lanes is	1	2	3	4	5	6	7	8	>8						
MT =	1.00	1.47	2.15	3.15	4.62	6.78	9.95								
where no. of main tracks is	0	1	2	3	4	5	>5								

APPENDIX D

VEHICLE FUEL, POLLUTION, AND DELAY COSTS AT CROSSINGS

A. Fuel Consumption Equations

Given: Community-wide total for affected vehicles by corridor

Queue duration

Affected vehicles at each crossing

Total delay

Average delay = 0.5BCT

Needed: Total fuel consumption by community
- -per corridor per day
- -per day (total)

Data: Average American Car ----- 1 cup of gasoline/6 min

= 0.1667 cup/min

=0.0104 gal/min

Consumption at idling ---- 0.006-0.015 gal/min

Calculation:

$$\text{Fuel consumed}_{city} = \frac{\text{consumption}}{\text{vehicle-minute}} \times (\text{total delay})$$

$$= (0.01\ \text{gal/veh-min})(\text{total delay}_{city})$$

B. Pollutant Emissions

Given: 151 kg/day CO emissions*

22 kg/day Hydrocarbon emissions*

97.8 vehicle-hours/day*

*Indiana study, Powell, 1982.

Needed: total pollutants emitted per day in kg

Equation:

$$P_{co} = (151\text{kg}) \times \left(\frac{1\ \text{day}}{97.8\ \text{veh-hr}}\right) \left(\frac{1\ \text{hr}}{60\ \text{min}}\right) (\text{veh-min of delay}_{city})$$

$$P_{hc} = (22\text{kg}) \quad \times \qquad \text{"}$$

C. Time Delay Cost

Given: Weekly wage/worker by county

Total delay

1 worker/vehicle assumed

Needed: the cost of delay in dollars

Equation:

$$\text{Delay cost} = \left(\frac{\$}{\text{worker-week}}\right)\left(\frac{1\ \text{worker}}{\text{vehicle}}\right)\left(\frac{1\ \text{week}}{40\ \text{hr}}\right)\left(\frac{1\ \text{hr}}{60\ \text{min}}\right)(\text{Total delay in veh-min})$$

Community (County)	Expected 1982 Average Weekly Wage
Rocky Mount (Nash)	$229.58
Wilson (Wilson)	250.28
Goldsboro (Wayne)	229.55
Warsaw (Duplin)	207.27
Wilmington (New Hanover)	258.86
Boiling Spring Lakes (Brunswick)	283.51
Greenville (Pitt)	241.21
New Bern (Craven)	276.15
Kinston (Lenoir)	246.59
Morehead City (Carteret)	203.36
Average	$ 6.07/hour assuming a 40-hr work week.

CEIP Publications

1. Hauser, E. W., P. D. Cribbins, P. D. Tschetter, and R. D. Latta. Coastal Energy Transportation Needs to Support Major Energy Projects in North Carolina's Coastal Zone. CEIP Report #1. September 1981. $10.

2. P. D. Cribbins. A Study of OCS Onshore Support Bases and Coal Export Terminals. CEIP Report #2. September 1981. $10.

3. Tschetter, P. D., M. Fisch, and R. D. Latta. An Assessment of Potential Impacts of Energy-Related Transportation Developments on North Carolina's Coastal Zone. CEIP Report #3. July 1981. $10.

4. Cribbins, P. S. An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone. CEIP Report #4. September 1981. $10.

5. Brower, David, W. D. McElyea, D. R. Godschalk, and N. D. Lofaro. Outer Continental Shelf Development and the North Carolina Coast: A Guide for Local Planners. CEIP Report #5. August 1981. $10.

6. Rogers, Golden and Halpern, Inc., and Engineers for Energy and the Environment, Inc. Mitigating the Impacts of Energy Facilities: A Local Air Quality Program for the Wilmington, N. C. Area. CEIP Report #6. September 1981. $10.

7. Richardson, C. J. (editor). Pocosin Wetlands: an Integrated Analysis of Coastal Plain Freshwater Bogs in North Carolina. Stroudsburg (Pa): Hutchinson Ross. 364 pp. $25. Available from School of Forestry, Duke University, Durham, N. C. 27709. (This proceedings volume is for a conference partially funded by N. C. CEIP. It replaces the N. C. Peat Sourcebook in this publication list.)

8. McDonald, C. B. and A. M. Ash. Natural Areas Inventory of Tyrrell County, N. C. CEIP Report #8. October 1981. $10.

9. Fussell, J., and E. J. Wilson. Natural Areas Inventory of Carteret County, N. C. CEIP Report #9. October 1981. $10.

10. Nyfong, T. D. Natural Areas Inventory of Brunswick County, N. C. CEIP Report #10. October 1981. $10.

11. Leonard, S. W., and R. J. Davis. Natural Areas Inventory for Pender County, N. C. CEIP Report #11. October 1981. $10.

12. Cribbins, Paul D., and Latta, R. Daniel. Coastal Energy Transportation Study: Alternative Technologies for Transporting and Handling Export Coal. CEIP Report #12. January 1982. $10.

13. Creveling, Kenneth. Beach Communities and Oil Spills: Environmental and Economic Consequences for Brunswick County, N. C. CEIP Report #13. May 1982. $10.

14. Rogers, Golden and Halpern, Inc., and Engineers for Energy and the Environment. The Design of a Planning Program to Help Mitigate Energy Facility-Related Air Quality Impacts in the Washington County, North Carolina Area. CEIP Report #14. September 1982. $10.

16. Frost, Cecil C. Natural Areas Inventory of Gates County, North Carolina. CEIP Report #16. April 1982. $10.

17. Stone, John R., Michael T. Stanley, and Paul T. Tschetter. Coastal Energy Transportation Study, Phase III, Volume 3: Impacts of Increased Rail Traffic on Communities in Eastern North Carolina. CEIP Report #17. August 1982. $10.

19. Pate, Preston P., and Jones, Robert. Effects of Upland Drainage on Estuarine Nursery Areas of Pamlico Sound, North Carolina. CEIP Report #19. December 1981. $1.00.

25. Wang Engineering Co., Inc. Analysis of the Impact of Coal Trains Moving Through Morehead City, North Carolina. CEIP Report #25. October 1982. $10.

26. Anderson & Associates, Inc. Coal Train Movements Through the City of Wilmington, North Carolina. CEIP Report #26. October 1982. $10.

27. Peacock, S. Lance and J. Merrill Lynch. Natural Areas Inventory of Mainland Dare County, North Carolina. CEIP Report #27. November 1982. $10.

28. Lynch, J. Merrill and S. Lance Peacock. Natural Areas Inventory of Hyde County, North Carolina. CEIP Report #28. October 1982. $10.

29. Peacock, S. Lance and J. Merrill Lynch. Natural Areas Inventory of Pamlico County, North Carolina. CEIP Report #29. November 1982. $10.

30. Lynch, J. Merrill and S. Lance Peacock. Natural Areas Inventory of Washington County, North Carolina. CEIP Report #30. October 1982. $10.

31. Muga, Bruce J. Review and Evaluation of Oil Spill Models for Application to North Carolina Waters. CEIP Report #31. August 1982. $10.

33. Sorrell, F. Yates and Richard R. Johnson. Oil and Gas Pipelines in Coastal North Carolina: Impacts and Routing Considerations. CEIP Report #33. December 1982. $10.

34. Roberts and Eichler Associates, Inc. Area Development Plan for Radio Island. CEIP Report #34. June 1982. $10.

35. Cribbins, Paul D. Coastal Energy Transportation Study, Phase III, Volume 4: The Potential for Wide-Beam, Shallow-Draft Ships to Serve Coal and Other Bulk Commodity Terminals along the Cape Fear River. CEIP Report #35. August 1982. $10.